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On all editorial matters, please contact Michael Huft, 232 Akela Dr., Valparaiso, IN 46385. Phone: (847) 682-5240; email: mhuft@att.net. All articles dealing with botany in the Great Lakes region may be sent to the Editor at the above address. In preparing manuscripts, authors are requested to follow the "Instructions for Authors" on the inside back cover.

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IN THIS ISSUE

Noel Pavlovic and colleagues have been studying the population dynamics of the Great Lakes shoreline endemic, Pitcher's thistle, *Cirsium pitcheri*, for some time. Their opening article in this issue contains a description, and first report, of fasciation in this iconic species. More than that, however, this fascinating article gives a brief account of fasciation in general (abnormal growth that produces contorted or flattened stems and inflorescences) throughout the flowering plants and discusses causes and the possible evolutionary significance.

The next article, by Robert Tatina, examines the composition of woody species in the canopy layer in comparison to that of the understory layer in the forested dunes along the southeastern shore of Lake Michigan to determine whether the forest is at an old-growth stage or at some early successional stage and, if the latter, to predict the future composition of the forest.

Dennis Riege's article is a contribution from his continuing series of studies on the forest composition of two white pine stands in the northwestern Upper Peninsula of Michigan, in this case, a study of the understory and ground vegetation of these stands in order to determine the relationship between understory and canopy diversity. Unlike most such studies, Dr. Riege's includes saplings of the canopy trees in the stands and discusses the effect of the inclusion of this element on the results.

In this day of environmental destruction, the restoration of natural areas is an important endeavor. Although it is natural to think of restoration as primarily an activity for rural areas, the paper by Christopher Bouma, Elizabeth Huizenga, and David Warners considers the efficacy of restoring small plots in an urban setting and asks whether such efforts are effective in attracting increasing diversity and higher trophic levels.

Daniel Carter and Matthew Pace report on their recent discovery of a rare orchid, *Spiranthes ovalis* var. *erostellata*, in southeastern Wisconsin, previously known in that state only from the far southwestern corner. This species, which is sparsely distributed throughout the eastern United States, reaches the northern edge of its range in the southern Great Lakes region, where the discovery of any new population is an event.

In recent years, Steve Chadde has written and published a number of field guides to the wetland plants, the general flora, and the pteridophytes of various states and regions in the western Great Lakes. Neil Harriman, a former editor of The Michigan Botanist, and a prolific contributor of reviews over the years, performs the great service of providing us with reviews of all of Mr. Chadde's books. Dr. Harriman skillfully distributes comments applicable to all or many of the books among the several reviews, while carefully delineating their differences. These reviews are thus best read in one or two groups. We publish here reviews of all the wetland guides, leaving the remaining reviews for a later issue.

Michael Huft

FIRST REPORT OF FASCIATION IN PITCHER'S THISTLE, *CIRSIUM PITCHERI* (ASTERACEAE)

Noel B. Pavlovic[1,2], Megan K. Korte[2], A. Kathryn McEachern[3], and R. Grundel[2]

[2]U.S. Geological Survey
1100 N. Mineral Springs Rd.
Porter, IN 46304

[3]U.S. Geological Survey
1901 Spinnaker Drive
Ventura, CA 93001

ABSTRACT

We document the first reported occurrence of fasciation in the federally threatened Pitcher's thistle, *Cirsium pitcheri* (Asteraceae). In 2013, we discovered two adult plants of Pitcher's thistle out of a total of 176 plants at West Beach, near Miller, Indiana, USA, that exhibited both normal and fasciated growth. Unlike plants with normal growth, a portion of the upper stems of these plants was flattened, and some flower heads were elongated into a fan-like shape. Each plant had one large fasciated terminal seed head and several less severely fasciated ancillary heads. The fasciated terminal head on one of the plants found produced an estimated 1153 seeds, whereas normal terminal heads typically produced 80 ± 9 viable seeds. The cause of this fasciation is unclear, but may be due to infection with phytoplasma.

KEYWORDS: Linear fasciation, Indiana Dunes National Lakeshore, phyllody, little leaf, seed production

INTRODUCTION

Fasciation is a morphological deformity in plants in which meristems become elongated transversely and produce wide banded stems, deformed leaves (referred to as "little leaf") and strange floral shapes (referred to as "phyllody") (White 1948). Fasciation is distinct from other forms of deformity, as classified by Choob and Sinyushin (2012). Deformity can occur in seed embryos, stems, leaves, and flowers (White 1948). In agriculture and horticulture, fasciation is a concern because of its potential to reduce crop production and thereby the value of trade plants (Wilson et al. 2001, Porbeni and Fawole 2013). On the other hand, fasciated plants can be of novelty interest and therefore perhaps salable in the floral and horticulture trades (White 1948). Cockscomb (*Celosia cristata,* Amaranthaceae) is perhaps the best known garden flower exhibiting fasciation. Cristate cacti are also quite popular in the floral trade.

Fasciation has been observed in a variety of species in over 100 plant families (Table 1, see White (1948) for a more complete species list). Many more examples and photographs can be found on the Internet (e.g., Royal Horticultural So-

[1] Author for correspondence (npavlovic@usgs.gov)

TABLE 1. Fasciation in vascular plant families and selected species.

Family	Species	Common name	Source
Amaranthaceae	*Celosia cristata* L.	Crested cockscomb	(White 1948)
Asteraceae	*Artemisia vulgaris* L.	Mugwort	(Battikhi 2002)
	Helianthus sp.	Sunflower	(Jambhulkar 2002)
	Ixeridium chinense (Thunb.) Tzvel.	China ixeris	(Li et al. 2013)
	Lactuca sativa L.	Lettuce	(Eenink and Garretsen 1980)
	Matricaria chamomilla L.	German chamomile	(El-Hamidi and Saleh 1964)
	Senecio stapeliiformi Phillips		(Omar et al. 2014)
Anacardiaceae	*Mangifera indica* L.	Mango	(Chaturvedi et al. 2003)
Apocynaceae	*Orbea gigantea* N. E. Br.	Starfish, Carrion flower	(Omar et al. 2014)
Brassicaceae	*Arabidopsis thaliana* (L.) Heynh.	Rockcress	(Suzuki et al. 2004);
	Beta vulgaris L.	Red beet	(Goldman 1998)
Cactaceae	*Austrocylindropuntia cylindrica* (Lam.) Backeb.	Cactus	(Omar et al. 2014)
Campanulaceae	*Pratia nummularia* (Lam.) A. Braun & Asch.	Star creeper	(Lina et al. 2003)
Celastraceae	*Celastrus orbiculatus* Thunb.	Oriental bittersweet	(Pavlovic, pers. obs. 2012);
Euphorbiaceae	*Euphorbia coerulescens* Haw.	Spurge	(Omar et al. 2014)
Fabaceae	*Cicer arietinum* L.	Chickpea	(Srinivasan et al. 2008)
	Glycine max (L.) Merr.	Soy beans	(Onda et al. 2011)
	Lathyrus sativus L.	Vetch	(Talukdar and Talukdar 2014)
	Pisum sativum L.	Pea	(Siniushin and Gostimskiĭ 2006)
	Spartium junceum L.	Spanish broom	(Reboredo and Silvares 2007)
	Vigna unguiculata (L.) Walp.	Cowpea or blackeyed pea	(Adu-Dapaah et al. 1999, Porbeni and Fawole 2013)
Liliaceae	*Lilium henryi* Baker	Lily	(Stumm-Tegethoff 1986, Akhtar et al. 2013)
Linaceae	*Linum usitatissimum* L.	Flax	(Pollini et al. 2002, Akhtar et al. 2013)
Oleaceae	*Olea europaea* L.	Olive	(Berkeley 1939, Pollini et al. 2002)
Scrophulariaceae	*Digitalis purpurea* L.	Digitalis	(Berkeley 1939, Ansari and Daehler 2011)
	Verbascum thapsus L.	Common mullein	(Rosenquist 1954, Ansari and Daehler 2011)
Solanaceae	*Solanum tuberosum* L.	Irish potato	(Rosenquist 1954)

ciety 2014, Ombrello n.d.). Fasciation may be caused by any of a variety of intrinsic and extrinsic factors. Intrinsic factors include genetic mutation (Srinivasan et al. 2008, Onda et al. 2011) and damage to plant tissue. Extrinsic factors include infection with phytoplasma, which are parasitic bacteria lacking cell walls and that are often transmitted by phloem-sucking insects (Wu et al. 2012, Akhtar et al. 2013), growth regulators (Iliev and Kitin 2011), actinomycete bacteria (Lina et al. 2003), herbicides (Bondada 2011), nematodes (Stumm-Tegethoff 1986), and radiation (Jambhulkar 2002). Much recent research has focused on the physiological, chemical, and morphological changes that produce fasciation (Fujita and Kawaguchi 2011, Iliev and Kitin 2011, Choob and Sinyushin 2012, Omar et al. 2014, Talukdar and Talukdar 2014) to understand the genetic mechanisms and pathways behind normal and abnormal plant development and growth (Fujita and Kawaguchi 2011). Whatever the cause, fasciation is the result of the transformation of the ring of meristematic cells into an elongate closed loop that produces widened stems and laterally elongated flowers or inflorescences.

In the course of the first author's investigation of seed predation by goldfinches on the federally threatened Pitcher's thistle (*Cirsium pitcheri* (Torr. ex Eaton) Torr. & A. Gray, Asteraceae), two fasciated individuals were noticed. In this article, we present preliminary information concerning the occurrence of fasciation in Pitcher's thistle and examine its impact on seed production in this species.

MATERIALS AND METHODS

Study Species

Pitcher's thistle is endemic to the western Great Lakes region, in particular to sand dunes along the shores of Lakes Huron, Michigan and Superior (Pavlovic et al. 2002). This lovely monocarpic perennial lives for two to eight years as a juvenile before flowering once and dying. Seedlings develop two to three true leaves. In juvenile plants, the number of leaves in the rosette increases with size and age. Flowering adults bolt in the early spring and are normally single-stemmed, although trampling or insect damage may induce growth of multiple shoots (Loveless 1984). Multiple heads are produced on each adult, of which the terminal head is the largest and the first to bloom. The terminal head is often subtended by one to three heads, and side braches have similar, but smaller terminal head arrangements with additional smaller heads in leaf axils. The heads are composed of numerous bisexual sessile florets on a common receptacle that is subtended by a series of involucral bracts. Pitcher's thistle is dependent on early successional dunes where vegetation cover is less than 50 percent (McEachern 1992, McEachern et al. 1994).

The Pitcher's thistle plants that exhibited fasciation were found growing at West Beach in the West Unit of the Indiana Dunes National Lakeshore (N 41° 37′ 26″ W 87° 12′ 33″) in northwestern Indiana at the southern tip of Lake Michigan. The Indiana Dunes National Lakeshore is an urban park of ca. 16,000 acres situated between Gary on the west and Michigan City on the east. It is known for the diversity of native habitats and the richness of its vascular plant flora (Pavlovic and Bowles 1996). Populations of Pitcher's thistle at the Indiana Dunes National Lakeshore and the Indiana Dunes State Park (together, the "Indiana Dunes") are at the southern limits of the range of the species (McEachern et al. 1994) and are genetically depauperate and inbred (Fant et al. 2013). Pitcher's thistle is threatened by droughts that limit establishment and by predispersal predation by goldfinches and introduced biocontrol weevils (Havens et al. 2012). Anthropogenic impacts include sand mining, trampling, shoreline erosion, and possibly nitrogen deposition and human-induced climate change.

Fasciated Plants

Two adult individuals of Pitcher's thistle were observed and were photographed, and the fasciated head of one of them was bagged at onset of seed maturation with a tan bridal veil to exclude seed predation by goldfinches and to collect the seeds (actually 1-seeded cypselae) after harvest. Because of the tightness of the inflorescence, 13 small subtending normal heads had to be included in the bag. Bagged heads were collected post-dispersal and were dissected in the lab. Full, flat, and aborted seeds, respectively, derived from these heads were counted. Because the heads dispersed into the bag, we were unable to separate the seeds from the long-fasciated head from those of the subtending heads. The number of seed scars on the top of the receptacles were counted to estimate the number of potential seeds that could be produced by each subtending head. We multiplied the number of scars by the proportion of total seeds that were full to estimate how many full seeds were produced by the subtending heads. This then allowed us to calculate the number of full seeds produced by the fasciated head. We measured the diameters of the fasciated terminal and subtending heads and compared those measurements to those of the normal terminal and subtending heads in the field during 2013. The width (measured across the axis of stem elongation) and the thickness of the stem (measured perpendicular to the axis of elongated stem) just below the fasciated head were measured. These measurements were compared to the stem diameters just below the terminal heads on two herbarium specimens located at the Indiana Dunes National Lakeshore herbarium (*Klick 2794*, *Hiebert 180*), each with three stems. Analysis of variance was performed to compare seed set and morphological measurements of fasciated and non-fasciated plants.

Because of the rarity and limited distribution of Pitcher's thistle, as well as its protected status, no voucher specimens were taken. The photographs accompanying this article will be sufficient to establish the identity of the plants that were studied.

RESULTS

The first fasciated plant was discovered on May 28, 2013, while mapping adult Pitcher's thistle plants (Figure 1A). It was growing to the east of a panne on a low slope at the edge of an anthropogenically-disturbed blowout south of the West Beach bathhouse. The second was discovered on June 10, 2013, growing 249 meters to the south of the first plant on a high southwest blowout dune slope (Figure 1B). Both plants were multiple-stemmed. The first plant had 17 stems, only one of which was fully fasciated. Two additional stems on this plant were slightly fasciated, each with a slight twist, and had slightly transversely-elongated terminal heads. Both individuals had portions of the stems fasciated as well as at least one fully fasciated terminal flowering head and some partially laterally expanded heads (Figure 1C). At the apex of the fasciated stem, flowering heads were clustered together, more prominently so in the second plant (Figure 1B). The fasciated heads appeared to bloom normally, and the florets did not exhibit virescence (green coloration).

The first and second plants had 78 and 26 flower heads, respectively, which was significantly greater than the mean number of heads counted on all other adults measured at West Beach in 2013 (N = 13), that is, 52 ± 9 (mean ± standard error) versus 15 ± 4 (analysis of variance: $F_{1,10} = 13$, $P = 0.005$). In normal adults, there are typically only one or two subtending heads just below the terminal head (1.5 ± 0.1). However, the second fasciated plant had 11 subtending heads just below the terminal head.

Normally the diameter of the stem below the terminal head averages 2.9 ± 0.3 mm (N = 6 for specimens in the Indiana Dunes National Lakeshore herbarium), whereas the fasciated stem was 2.2 mm thick and 12.3 mm wide on the first plant

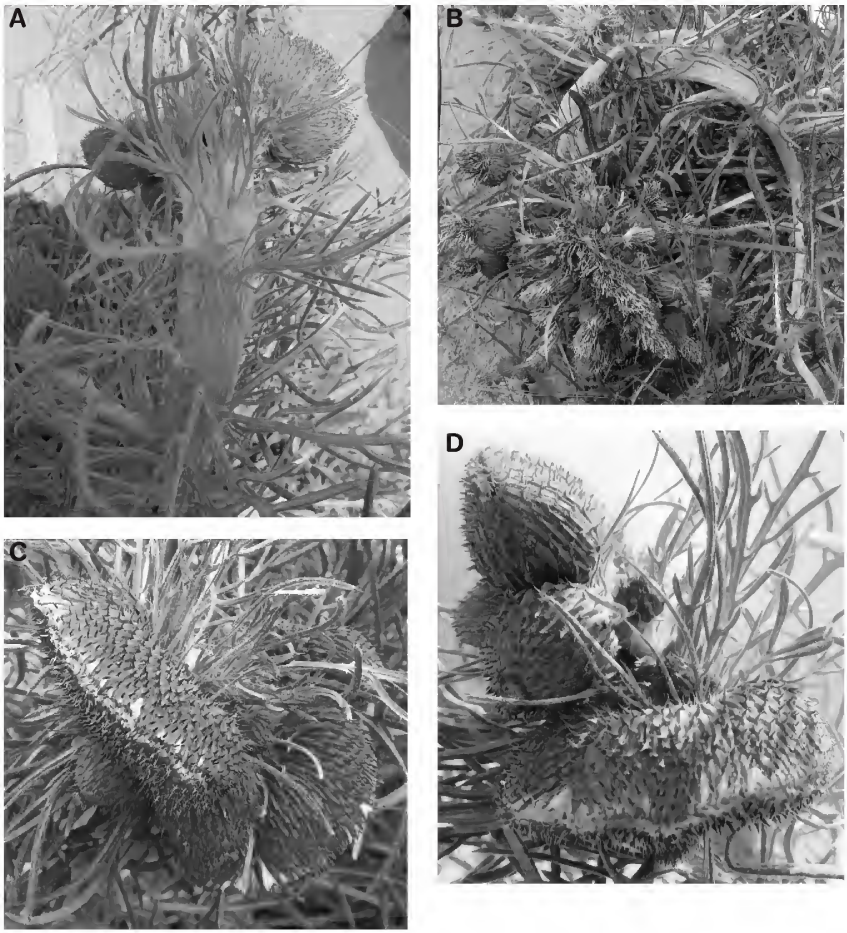

FIGURE 1. Fasciated plants of Pitcher's thistle. A. First plant discovered showing banded stem, little leaf, and fasciated heads. B. Second plant discovered showing banded stem and cluster of ancillary heads surrounding the laterally elongated terminal head. C. Fasciated head in bud. D. Fully elongated head and partially elongated heads.

and 1.8 mm thick and 15 mm wide on the second plant (Figure 1B). Along the narrow dimension, thickness varied due to the presence of longitudinal ridges that are called linear fasciation.

Typical terminal heads measured in demography plots that had been established in 1988 throughout the Indiana Dunes National Lakeshore averaged 25.1 ± 0.5 mm (N = 79) in diameter in 2013 (Figure 2A). The fasciated head varied in thickness between 20.2 and 26.9 mm, but the extended length of the head was approximately 64.7 mm (Figures 2B, 2D). This length is 2.58 times the average

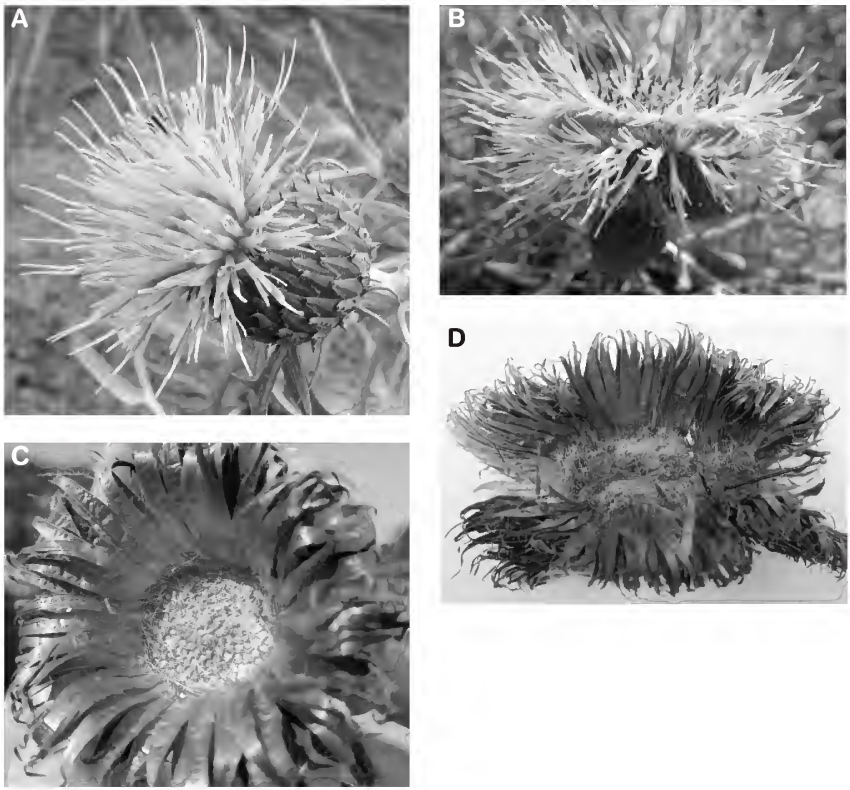

FIGURE 2. Comparison of normal and fasciated heads of Pitcher's thistle. A. Normal round head of Pitcher's thistle in bloom. B. Fasciated head in bloom. C. Inner view of top of receptacle of normal head showing scars where flowers/seeds were attached. D. Inner view of receptacle in fasciated head from the second plant.

diameter. The eleven subsidiary heads had an average diameter of 19.4 ± 0.8 mm.

The total number of seeds produced by the terminal fasciated head (plant 2) and the 13 ancillary heads together was 2219, of which 1871 (or 84.3%) were full, 23 (or 1.0%) were flat, and 325 (or 14.6%) were aborted. The 11 ancillary heads produced an estimated 718 full seeds, calculated by multiplying the percentage of all full seeds (84.3%) by the number of scars on the subsidiary heads (851), yielding a total estimate of 1153 for the number of full seeds in the fasciated head (see scars in Figures 2C, 2D). This is 14 times more seed than is produced by a normal terminal head.

DISCUSSION

Fasciation is often considered a novelty, and it creates plant forms that are often called "living sculptures" (Omar et al. 2014). Species exhibiting fasciation are often popular in the floral and horticultural trade. In other instances fasciation can be considered a disease that needs to be eradicated so that seed production of impacted agricultural crops is unimpaired (Porbeni and Fawole 2013). In the case of Pitcher's thistle, fasciation is a novelty that seems quite rare, and its cause is obscure. Depending on the cause of the fasciation, it is possible that it could play an evolutionary role in creating new species; however, rarely has the evolutionary significance of fasciation been explicitly discussed. Rudall (Rudall 2008) discusses the hypothesis that fasciation might have led to the evolution of carpel arrangements in some species in the Triuridaceae. Although Choob and Sinyushin (2012) discuss the genetic and physiological mechanisms that create alterations in the shoot apical meristem and floral meristem, they believe that fasciation is a natural expression of physiological changes rather than a disturbance in the genetic control of development. Nevertheless if fasciation can be caused by genetic mutation, it could be subject to natural selection.

Pitcher's thistle exhibited linear fasciation with widened stems, stem thickenings, and widened flowers (Choob and Sinyushin 2012). Characteristics typical of phytoplasma-induced fasciation include floral virescence, phyllody, little leaf, stunting, and stem fasciation (Akhtar et al. 2013). We did not observe either floral virescence or a failure to produce seeds, which is often a result of phyllody, in any of the plants we examined. It is unclear what produced the fasciation in the two adult plants. If seed collected from the plant produces fasciated seedlings, juveniles, or adults that are not infected with phytoplasma progeny, then a genetic cause would be likely. However, it is also possible that the transmission of phytoplasma to the progeny through the seeds would produce a similar effect. Further reports of fasciated heads would be important in determining the frequency of their occurrence and geographical distribution throughout the range of Pitcher's thistle. If the fasciation is caused by a phytoplasma, then the identity and origin of the phloem-sucking insect or insects would be informative. Additional research will be required to determine the origin of this unusual morphology in Pitcher's thistle.

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SUCCESSIONAL STATUS AND DEMOGRAPHY OF THE FORESTED DUNES AT WARREN DUNES STATE PARK, BERRIEN COUNTY, MICHIGAN

Robert Tatina
Biology Department
Dakota Wesleyan University
Mitchell, SD 57301
rotatina@dwu.edu

ABSTRACT

The presettlement vegetation of much of Warren Dunes State Park in southwestern Michigan is thought to have been mostly a dry-mesic southern forest of oaks and hickories. Since the 1800s, the forests probably have been logged at least once, if not more often, after which the forests began to undergo secondary succession. The objectives of the current study were to determine if successional changes are still occurring and what the future composition of the forest might look like as a consequence of those changes. Relative densities of species of trees in the canopy and the understory layers, sampled along transects in the upland forested areas of the dunes were used to determine the successional status of the forest and to predict its future composition. Currently, the forest is dominated in both the canopy and the understory layers by *Quercus rubra* L. and *Acer saccharum* Marshall. Comparisons of the relative densities of species in the canopy layer with those of species in the understory layer show that the forest is in some mid- to late-successional stage. When absolute densities were plotted against size classes, a negative exponential distribution resulted, suggesting that the forest is replacing itself. Future changes in the composition and structure of the forest are explained relative to species characteristics and interactions.

KEYWORDS: Warren Dunes State Park, forest composition, succession

INTRODUCTION

Ecological succession involves all of the processes that bring about changes in the composition and structure of biotic communities over time. As succession proceeds, species populations replace one another, until eventually an old growth community results (Oliver and Larson 1996). At this point, in deciduous forests, a dynamic equilibrium is attained in which reciprocal replacement occurs as one tree of a dominant species locally replaces another in gaps formed when a canopy tree is toppled (Brewer and Merritt 1978; Poulson and Platt 1996; Woods 1979). Gap replacement thereby produces old growth forests that are multi-layered and uneven-aged in which dominance is shared by shade-tolerant species. Old growth forests also exhibit an understory species composition (i.e., seedlings and saplings) that is similar to that of the canopy and thus are self-replacing (Oliver and Larson 1996).

In southwestern Michigan, the self-replacing old growth forest has been described as one in which the dominant tree species are *Fagus grandifolia* Ehrh. and *Acer saccharum* (Cain 1935; Brewer et al. 1984). However, this area, like most, was a mosaic of forested community types (Kost et al. 2002). Thus, on the

dunes along the southeastern end of Lake Michigan, a forest of oaks and hickories, supposedly similar to the dry-mesic southern forest of Kost et al. (2007), occupied much of the area (Comer et al. 1995) with pockets of *Tsuga canadensis* (L.) Carrière and *Pinus strobus* L. (Kost et al. 2002). However, few such forests now exist in the state due to extensive logging or to clearing for agriculture and other types of development and the concomitant exclusion of fire. As a result, the forests that have repopulated these areas are in some stage of secondary succession.

Greenberg (2002) bemoaned the lack of information about the natural features of Warren Dunes State Park (the "Park") in spite of the floristic work of Wells and Thompson (1982). However, since then, two papers have increased the knowledge base of the Park. Smith and Woodland (2006) presented a floristic inventory of the Park in which they listed 712 vascular plant species, of which about three-fourths are native. Then, as a follow up to the work of Wells and Thompson (1982), Smith and Woodland (2007) described the floristic composition of the upland forests in the Park, reporting that these forests were "mature and potentially old growth stands" in which dominance was shared by *Quercus rubra* and *Acer saccharum*. Although the studies of Wells and Thompson (1982) and of Smith and Woodland (2007) provide excellent descriptions of the current species composition of the upland forest, they do not document its successional status or the reproductive dynamics that might predict the future of the forest.

One of the two objectives of this study was to determine whether the upland forest at Warren Dunes State Park had attained old growth status or is instead at some seral stage leading up to it. This objective will be accomplished by comparing the relative densities of the canopy species with the relative densities of the understory species that grow beneath them. The assumption underlying this procedure is that if the relative densities of each understory species are similar to those of the same species in the canopy, then the understory species are poised to replace the canopy species, and the forest may thereby be self-sustaining. If the relative densities in the two layers differ markedly, then the composition of the forest is in some mid-successional stage and will probably change over time. The combined absolute density of all species will then be plotted by size classes. If a negative exponential distribution results, this would indicate that the forest is uneven-aged and reproducing itself, whereas a unimodal distribution would indicate that the forest is even-aged and may be in decline (Holmes 2006).

The second objective of this study was to use demographic data to predict the future composition of the forest. For this objective, the reproductive effort of each species, as measured both by the number of seedlings per canopy tree and the number of saplings per canopy tree, will be used to predict the future abundance of that species, based on the assumption that if the ratio is high the species may be replacing itself. If it is low, the species may be in decline.

MATERIALS AND METHODS

Study area

Warren Dunes State Park contains 789 hectares of forested dunes located along the southeast shore of Lake Michigan in Berrien County, Michigan (Figure 1). In 1919, the land occupied by the

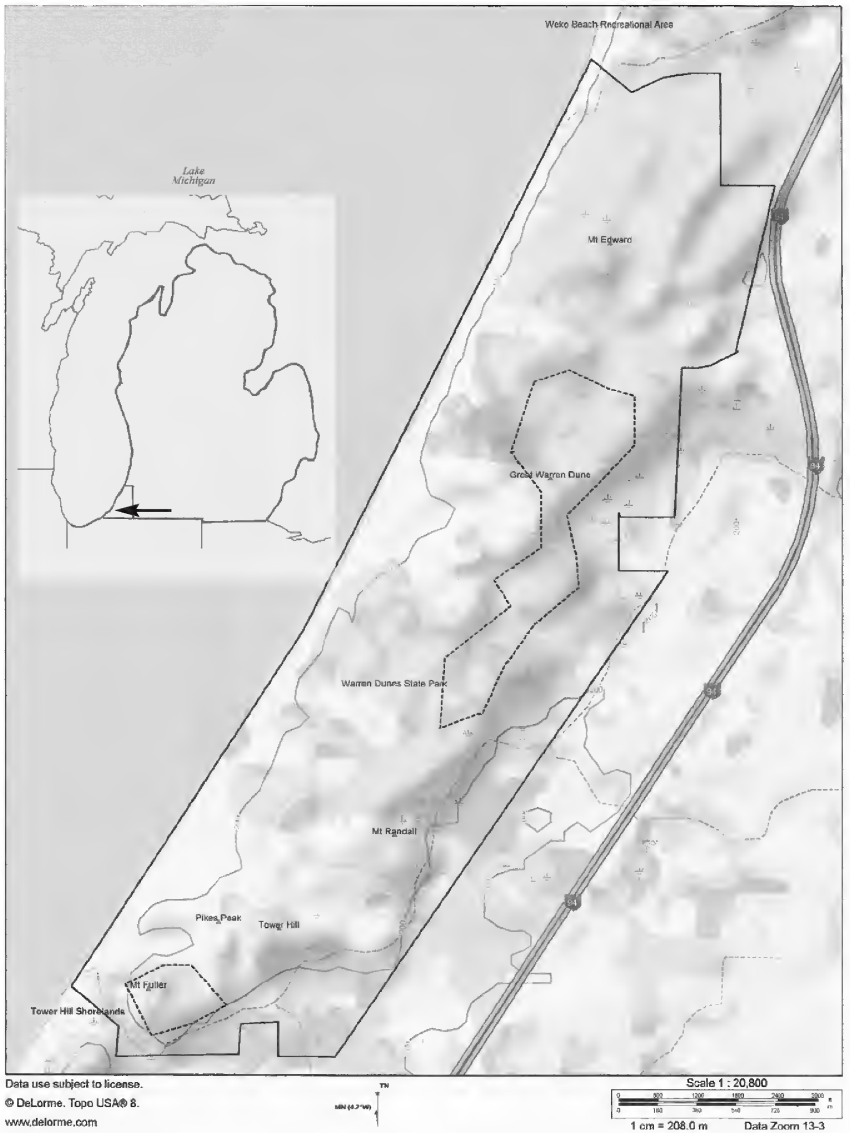

FIGURE 1. Warren Dunes State Park. Dashed lines indicate sampling areas. The arrow on the inset map of Michigan indicates the location of the Park within Berrien County.

southern portion of the Park was leased to the state of Michigan by the E. K. Warren Foundation. At that time it was set aside as a natural area from which logging was excluded (Ruthven 1919). The natural features of the Park (Kost et al. 2002) and its history, geology and soils (Kost et al. 2002; Smith and Woodland 2006) have been previously described.

Procedure

During the summers of 2010 and 2011, transects were run along contour lines at various locations within the forested upland portions of the Park (Figure 1). Transects were located at bases of slopes, at mid-slope, and along crests of inactive parabolic dunes in an attempt to sample the diversity of forested microhabitats. For purposes of this study, individuals of tree species were divided into three size classes: (i) adults, individuals whose diameter at breast height (DBH) is ≥10 cm; (ii) saplings, whose DBH is <10 cm and whose height is ≥30 cm; and seedlings, whose height is <30 cm. Saplings and seedlings as defined above comprise the understory. Breast height was taken to be 1.4 m. Along the transects, 310 sampling points were randomly located a minimum of 20 m apart. At each sampling point, two adults were selected for measurement, following the t-square plotless method of Greenwood (1996). After the adult nearest to a sampling point had been chosen, the distance (m) between its center and the sampling point was measured. In addition, the circumference of the adult at breast height was measured. The second adult to be measured was the nearest neighbor to the first adult growing beyond a line drawn through the first adult and perpendicular to a line extending from the sampling point to the first adult. The distance between the first adult and the second adult was then measured, as was the circumference of the second adult at breast height.

Saplings were counted in 0.01 ha circular plots whose radii extended from each sampling point. Each sapling was assigned to one of five DBH classes (<2, <4, <6, <8 and <10 cm), which had 1, 3, 5, 7, and 9 cm size class midpoints, respectively. Seedlings of each species were counted in 0.002 ha circular plots centered on each sampling point.

The various measures of density of the adults of each species were calculated from distance measurements as follows: (1) the *total density* (individuals per m^2) of all species was calculated as $n^2/2.828\Sigma x\Sigma y$ (Greenwood 1996), in which n is the number of sampling points, x is the distance (m) to the nearest adult from a sampling point, and y is the distance (m) from the first adult to its nearest neighbor; (2) the *relative density* of each species was determined by dividing the tree count of each species by the total number of trees sampled; and (3) the total density (individuals per m^2 * 10000 $m^2 \cdot$ per ha) of all species was then multiplied by the relative density of each species, which yielded the *absolute density* for each species in number of individuals per hectare. The absolute density of the saplings and the seedlings of each species was calculated by dividing the number of individuals counted by the total area sampled. After the sapling and seedling absolute densities for each species were added together, these combined values were totaled and then used as the divisor to yield the relative density of understory individuals for each species. The number of saplings per adult for each species was determined by dividing the sapling density (individuals per hectare) of a species by the density (individuals per hectare) of adults of the same species. A similar calculation using the density of seedlings was done to yield the number of seedlings per adult for each species. Separately calculating the ratios of seedlings and saplings to adults allowed for a more detailed examination of the source of the reproductive effort of each species.

Determining if the relative densities of adults and of understory individuals for a given species were related was done by chi square (χ^2) analysis (Zar 1984) performed on a contingency table of their absolute densities, setting $\alpha = 0.05$. A Bray-Curtis coefficient of similarity (Bray and Curtis 1957) was calculated to determine the similarity between the relative densities of adults and the relative densities of understory individuals. Finally, the sums of the absolute densities of all tree species were plotted by size class. As noted earlier, the resulting pattern allows one to determine if the forest is replacing itself or if it is in decline.

The following species were found as seedlings and saplings only and were therefore not included in this study: *Ailanthus altissima* (Mill.) Swingle (tree-of-heaven), *Amelanchier arborea* (F. Michx.) Fernald (serviceberry), *Carpinus caroliniana* Walter (hornbeam), *Cornus sericea* L. (red osier), *Hamamelis virginiana* L. (witch-hazel), *Morus rubra* L. (red mulberry), *Prunus virginiana* L. (choke cherry), and *Ptelea trifoliata* L. (wafer-ash).

Nomenclature follows that of Voss and Reznicek (2012).

RESULTS

Table 1 lists the relative densities of all tree species by adult and by understory size classes. This list contains the same species as those found along transects by Smith and Woodland (2007, Table 4) except that *Quercus velutina* Lam. (black oak), *Populus deltoides* Marshall (eastern cottonwood), *Thuja occidentalis* L. (northern white cedar), and *Acer nigrum* F. Michx. (black maple), all of which occurred at very low Importance Values in their study, were not sampled in the current study. *Quercus rubra* and *Acer saccharum* were the species with the highest metrics (Relative Density or Importance Value) in both studies. For all individuals greater than 4 cm DBH, the 634.3 individuals per hectare in the current study falls well within the range (432.9–781.0) reported by Smith and Woodland (2007).

Generally, both the canopy and the understory layers contained the same species and were dominated by *Quercus rubra* and *Acer saccharum.* However, the Bray-Curtis coefficient of similarity of their relative densities was low (30.89%), indicating that the two layers are not similar. The relative density of adults (23.13%) of *Quercus rubra* exceeded the relative density of its understory individuals (19.71%), whereas the relative density of adults of *Acer saccharum* (20.68%) was less than that of its understory individuals (36.80%) (Table 1). For the subdominants, *Tsuga canadensis*, *Tilia americana* and *Fagus grandifolia*, the relative density of understory individuals was lower than that of the adults, as was the case for the less abundant species (e.g., *Ostrya virginiana* (Mill.) K. Koch, *Liriodendron tulipifera* L., *Acer rubrum*, *Quercus muehlenbergii* Engelm., *Q. alba* L., and *Betula alleghaniensis* Britton. For two of the subdominants, *Sassafras albidum* (Nutt.) Nees and *Carya cordiformis* (Wang.) K. Koch, the relative densities of saplings exceeded those of the adults. Some species with minor contributions to the composition of the forest (e.g., *Fraxinus americana* L., *Prunus serotina* Ehrh., *Nyssa sylvatica* Marshall and *Ulmus rubra* Muhl. also exhibited higher relative densities of understory individuals than of the adults. Finally, while the relative densities of adults and of understory individuals differ, they are not independent ($\chi^2 = 11054$, df = 20, $P < 0.05$).

Figure 2 shows the combined absolute density of all tree species by size classes and exhibits a negative exponential distribution in which there is a sharp decline in densities from seedlings to saplings and adults. A similar distribution was noted by Pinheiro (2008) for both an old growth and a second growth beech maple forest in north-central Ohio as indicative of an uneven aged forest that is generally replacing itself. It does not, however, indicate the future composition of the forest.

The reproductive effort of trees at Warren Dunes State Park is presented in Table 1 as measured by both the ratios of seedlings to adults and saplings to adults. It is apparent that the ratio of seedlings to adults is generally higher than the ratio of sapling to adults. Species with high numbers of seedlings per tree (i.e., ≥100) were *Ulmus rubra* and *Cornus florida* L. Those with moderate numbers (i.e., <100 and ≥20) included *Quercus rubra*, *Acer saccharum*, *Sassafras albidum*, *Carya cordiformis*, *Acer rubrum*, *Fraxinus americana*, *Prunus serotina*,

TABLE 1. A comparison, for each woody species at Warren Dunes State Park, of (i) the relative density of adults and of understory individuals (i.e., saplings plus seedlings), and (ii) the reproductive effort as measured by the number of seedlings per adult and the number of saplings per adult.

	Relative Density		Reproductive Effort	
Species	Adults	Understory Individuals	Seedlings per Adult	Saplings per Adult
Quercus rubra northern red oak	23.13	19.71	24.25	0.36
Acer saccharum sugar maple	20.68	36.80	38.26	13.14
Tsuga canadensis eastern hemlock	14.50	0.86	0.11	1.59
Tilia americana basswood	9.93	1.37	2.18	1.80
Fagus grandifolia American beech	6.35	0.84	0.58	3.26
Sassafras albidum sassafras	5.54	15.67	55.62	26.12
Carya cordiformis bitternut hickory	3.42	5.73	46.04	2.39
Ostrya virginiana hop-hornbeam	3.09	1.97	4.75	13.66
Liriodendron tulipifera tuliptree	2.77	0.19	1.33	0.65
Acer rubrum red maple	2.12	1.97	25.05	1.77
Quercus muehlenbergii chinkapin oak	1.63	0.51	6.76	2.30
Quercus alba white oak	1.47	0.10	1.67	0.39
Fraxinus americana white ash	1.78	5.19	94.51	59.71
Prunus serotina black cherry	1.30	3.83	79.53	5.45
Betula alleghaniensis yellow birch	0.33	0.03	1.25	1.50
Nyssa sylvatica blackgum	0.49	1.23	39.24	33.23
Acer saccharinum silver maple	0.33	0.01	0.00	1.00
Celtis occidentalis northern hackberry	0.33	0.36	15.03	16.53
Ulmus rubra slippery elm	0.33	1.56	101.45	37.32
Cornus florida flowering dogwood	0.33	2.05	123.99	57.36
Pinus strobus white pine	0.16	0.01	0.00	1.50
Totals	**99.99**	**100.00**		

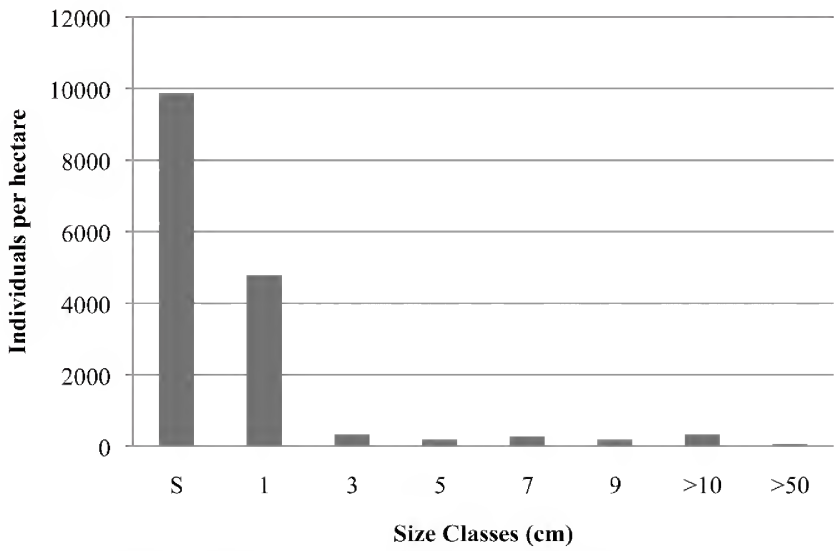

FIGURE 2. Absolute density (individuals per hectare) by size class for all tree species at Warren Dunes State Park. The distribution of individuals depicts a forest that is replacing itself. S indicates the seedling size class; 1, 3, 5, 7, and 9 indicate sapling size classes with midpoints at 1, 3, 5, 7, and 9 cm DBH, respectively; and >10 and >50 are canopy tree size classes (in cm DBH). Although not shown well on the scale of this chart, the >50 size class had 62 individuals

and *Nyssa sylvatica*. Low numbers of seedlings per adult (i.e., <20) were recorded for *Tsuga canadensis*, *Tilia americana* L., *Fagus grandifolia*, *Ostrya virginiana*, *Liriodendron tulipifera*, *Quercus muehlenbergii*, *Q. alba*, *Betula alleghaniensis*, and *Celtis occidentalis* L.

Several species had high sapling to adult ratios (≥35), most notably *Sassafras albidum*, *Fraxinus americana*, *Prunus serotina*, *Nyssa sylvatica* and *Ulmus rubra*. Those with moderate ratios (<35 and ≥5) included *Acer saccharum*, *Celtis occidentalis* and *Ostrya virginiana*. Among those with low ratios (<5) were *Quercus rubra*, *Tsuga canadensis*, *Tilia americana*, *Fagus grandifolia*, *Carya cordiformis*, and *Liriodendron tulipifera*.

DISCUSSION

According to Wilder et al. (1999), if the species composition of a plant community differs between the canopy layer and the understory layer, the plant community is not self-sustaining, but is at some mid-stage of succession. Although Smith and Woodland (2007) conclude that the forest at the Park is old growth based on the large number of large trees and the average distance between them, they note that *Quercus rubra*, one of its dominants, is a mid-successional

species. In the present study, the differences between the relative densities of the canopy trees and of the seedlings and saplings that will replace them indicate that the composition of much of the forest at the Park is changing. Even if the current climatic conditions do not change markedly, the species composition of this forest will change, even as *Acer saccharum* retains its position as one of the dominants. Additional support for this conclusion comes from sugar maple's moderate sapling to adult (13.14:1) and large seedling to adult (38.26:1) ratios (Table 1). By both of these measures, *A. saccharum* seems to be recruiting a sufficient number of individuals into larger size classes to be considered a growing population. Its browse tolerance under herbivory (Long et al. 2007), a feature that has been attributed in part to potent defensive compounds contained in its leaves (Barbehenn et al. 2005), and its shade tolerance (Barnes and Wagner 2004) may contribute to its persistence as a canopy dominant. In addition, this species has been reported to convert soil nitrogen to nitrate, which, being highly water-soluble, is easily leached from the root zone of the sandy soils of the dunes, thereby reducing the fertility of the soil and perhaps lowering the competitive ability of other species (Lovett and Mitchell 2004).

Quercus rubra, which is codominant with *Acer saccharum* at the Park, shows signs of decreasing in abundance. First, the relative density of its understory individuals (19.71) is lower than that of its canopy trees (23.13) (Table 1); and second, its sapling per adult ratio (0.36:1) is very low (Table 1). The moderate seedling to adult ratio (24.25:1) that it exhibited is probably the result of recent pulsed reproduction (Sander 1990). Its lower shade tolerance compared to *A. saccharum* (Nowacki et al. 1990) and the higher incidence of herbivory on its fruits, seedlings, and saplings (Gysel, 1957; Long et al. 2007; Long et al. 2012) make it less competitive than *A. saccharum*. In addition, Lorimer et al. (1994) have suggested that understory trees of other species may inhibit seedlings of *Q. rubra*. Finally, if *A. saccharum* decreases the fertility of the soil (Lovett and Mitchell 2004), the competitive ability of *Q. rubra* may be reduced because it has a greater nutrient demand than *A. saccharum* (Barnes and Wagner 2004).

The subdominants—*Tilia americana*, *Tsuga canadensis*, and *Fagus grandifolia*—are probably in decline also since the relative density of the understory individuals of each of these species was lower than that of the adults and the ratios of understory individuals to adults were also very low (Table 1). *Tilia americana* is shade intolerant, and its seedlings very rarely become established (Curtis 1959), thereby making increases in its abundance highly unlikely. However, it produces abundant sprouts from the root crown of mature trees, one or more of which may replace the parent at the parent's demise.

In the coves of the dunes at the Park are stands of *Tsuga canadensis*, a species showing population decline because of its very low reproductive effort (Table 1). *Tsuga canadensis* seedlings are heavily browsed by deer, which can cause a lack of effective reproduction when deer populations are high (Barnes and Wagner 2004). Nevertheless, because this species is extremely long lived (600 years, Barnes and Wagner 2004), the presence of only a few seedlings and saplings at any given time might be sufficient for it to replace its canopy trees.

Fagus grandifolia suffers from low reproductive effort because its small seed crop is heavily preyed upon (Cain 1935), but, like trees of *Tilia americana*, it can

produce root sprouts that may grow into the canopy when a gap occurs. As a result, *Fagus grandifolia* may remain a minor component of the canopy for some time; however, as the oaks decline and produce canopy openings, *F. grandifolia* may grow into those gaps, as it has been shown to do in nearby forests (Poulson and Platt 1996; Woods 1979). In addition, adults of *F. grandifolia* may be able to suppress *Acer saccharum* seedlings by allelopathy (Hane et al. 2003) and thereby eventually become codominant with *A.saccharum.*

Six species—*Fraxinus americana*, *Prunus serotina*, *Sassafras albidum*, *Carya cordiformis*, *Nyssa sylvatica*, and *Ulmus rubra*—exhibited characteristics of self-replacement. Each had understory relative densities that exceeded adult relative densities, had high to moderate seedling to adult ratios (except for *Carya cordiformis*), and high sapling to adult ratios (except for *Carya cordiformis*). However, because of being plagued by the emerald ash borer, there may be little advanced reproduction of *Fraxinus americana* in the future. *Prunus serotina* and *Sassafras albidum* are shade intolerant (Barnes and Wagner 2004), and, unless there are openings in the canopy, their understory individuals may produce very few canopy size trees. Given the prediction that global temperature increases will increase the frequency and strength of storms (NCADAC 2013), there may be increased blowdown of canopy trees and thus more openings in the forest for *Sassafras albidum* and *Prunus serotina* to become part of the canopy. *Carya cordiformis* is nowhere in its range a dominant or subdominant species because it is shade intolerant (Smith 1990). Although *Nyssa sylvatica* is shade tolerant and is a prolific root sprouter, it will increase mostly at the death of parent trees, and then mostly on wet-mesic sites. According to Cooley and Sambeek (1990), although *Ulmus rubra* is shade tolerant and capable of producing root sprouts, it is subject to Dutch elm disease. It therefore seems likely that none of these three species will be more than minor components of the forest in the Park in the future.

Five species—*Liriodendron tulipifera*, *Acer rubrum*, *Quercus muehlenbergii*, *Q. alba*, and *Betula alleghaniensis*—may be in decline as evidenced by their very low sapling to adult ratios and, except for *Acer rubrum*, their very low seedling to adult ratios (Table 1). In simulations of succession using data from eastern deciduous forests, Busing (1995) predicted that *Liriodendron tulipifera* would be eliminated after about 500 years if large gaps were not present. Although it is low in abundance at the Park, it may remain at low levels in the absence of major disturbance. Neither *Acer rubrum* (Russell and Yawney 1990), *Quercus muehlenbergii* (Sander 1990), nor *Q. alba* (Abrams 2003) can compete under a closed canopy. They are favored by fire, which, if suppressed, will prevent them from competing effectively. *Betula alleghaniensis*, being a pioneer species, cannot regenerate under a closed canopy (Erdmann 1990) and has been found to be inhibited by extracts from roots of sugar maple (Tubbs 1973), two conditions which may explain its decline.

The conclusion to be drawn from the data is that the canopy composition of the forest at the Park will change. Currently, it is a sugar maple-northern red oak forest, but over time it may become one dominated by sugar maple alone with lesser abundances of other shade-tolerant species.

Smith and Woodland (2007) explain the current dominance of *Quercus rubra*,

a successional species (as indicated by its intermediate shade tolerance, Barnes and Wagner 2004), by invoking the geologically young age of the dunes at the Park, which Hansen et al. (2010) indicate are between 3300 and 4400 years old, and the mesic conditions and absence of fire which promote it. However, past logging may have played a significant role in shaping the current forest community by opening gaps into which *Q. rubra* saplings could grow. It seems unlikely that the forest at the Park escaped logging before 1900 since a pier (Browns Pier) and horse-drawn rail way existed at the southern boundary of the park (Ellis 1880; Coolidge 1906), and a similar pier (Plummers Pier) was located immediately north of the park—see map in Smith and Woodland (2007) and discussion in Coolidge (1906). Because *Q. rubra* is a faster growing species than *Acer saccharum* (Barnes and Wagner 2004), it would have reached the canopy after logging before *A. saccharum* would have. However, after canopy closure, *A. saccharum*, which is more shade tolerant than *Q. rubra* (Barnes and Wagner 2004), would be able to recruit individuals into canopy size classes more effectively than would *Q. rubra*.

Logging alone, however, may not be a sufficient cause for the mid-successional status of the forest at Warren Dunes State Park. Kost et al. (2002) suggest that fire may have played an important role since ". . . many of the oaks, especially those along ridge tops, appeared to be open-grown, suggesting that the area once supported a fire dependent oak barrens or oak savanna community." *Quercus rubra* would have been selected for because it is able to resprout from root crowns after a fire, whereas *Acer saccharum* is not (Christianson 1971; Albert and Minc 1987). This would have allowed *Q. rubra* seedlings to be recruited into larger size classes ultimately to become a canopy dominant. As *Q. rubra* became dominant, the canopy closed, a condition that selects for shade tolerant species, such as *A. saccharum*, but not shade intolerant species, such as *Q. rubra*. A similar situation was reported by Crow (1992) in Wisconsin. Later, fire exclusion would also promote *A. saccharum* (Tyrell 2003). This scenario would seem to account for the current dominance of *Q. rubra* and its future reduction in importance as *A. saccharum* replaces individuals of *Q. rubra* that are lost through old age, disease, wind throw, etc. In addition, *Q. rubra* seedling growth may be inhibited through negative effects on oak ectomycorrhiza as Dickie et al. (2002) reported for *Acer rubrum* on *Q. rubra*.

In summary, the forest at Warren Dunes State Park is at some mid- to late-successional stage in which dominance is shared by *Quercus rubra*, a successional species, and *Acer saccharum*, an old growth forest dominant; in general, the species composition is changing as the forest replaces itself. In the future it may become a beech-maple forest as *Q. rubra* is replaced by *A. saccharum* and then by *Fagus grandifolia*, so that the forest may then look more like that described for the Warren Woods State Park by Cain (1935) and by Donnelly and Murphy (1987).

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GROUND VEGETATION OF OLD-GROWTH WHITE PINE STANDS AT THE HURON MOUNTAIN CLUB RESERVE AND ESTIVANT PINES IN UPPER MICHIGAN

Dennis A. Riege
University of Maryland University College
17 Longmeadow Avenue
Middletown, RI 02842
driege@umuc.edu

ABSTRACT

Because understory dynamics of late-successional forests are little understood, examination of the composition and change of ground vegetation was included in long-term permanent plot studies of two preserved forests in Upper Michigan. Adjacent plots in the Huron Mountain Club Reserve included a *Pinus strobus–Tsuga canadensis*–northern hardwoods forest and an atypical *Pinus strobus–Picea glauca* stand with dense undergrowth of *Acer saccharum* saplings. At Estivant Pines one plot contained a stand of *Pinus strobus–Acer saccharum–Abies balsamea*, and the second plot held a similar stand with large gaps. The presence of all species of vascular plants on the forest floor was recorded in transects of continuous 2 × 2 m quadrats across the plots. Species in the Huron Mountain Club Reserve plots were typical of old-growth upland conifer–northern hardwoods stands, in which *Acer saccharum* seedlings, *Maianthemum canadense*, and *Dryopteris carthusiana* were the most common components. Community composition indicated wet-mesic conditions at one of the plots and mesic conditions at the other. Understory species richness was greatest in the plot in which *Tsuga canadensis* is a co-dominant, a result opposite that of most previous studies. Species richness was less in the dry-mesic Estivant Pines plots, in which tree seedlings constituted the bulk of the richness, than in the Huron Mountains plots. Ground vegetation in the plot at Estivant Pines without gaps was dominated by *Thuja occidentalis* seedlings, which may have suppressed other species. The vegetation at both sites indicated that deer herbivory was relatively light in comparison to other regional studies. Future studies in these long-term permanent plots will investigate intrinsic late-successional dynamics of these forests, as well as the effects of extrinsic forces, such as herbivory.

KEYWORDS: *Pinus strobus*, Huron Mountains, Estivant Pines, species richness, ground vegetation

INTRODUCTION

Long-term permanent plot studies are needed to test theoretical patterns of succession and to suggest hypotheses on vegetation dynamics (Bakker et al. 1996; Johnson and Miyanshi 2008). Permanent plots that monitor understory changes in late-successional forests are especially rare. Vegetation dynamics of ground communities are poorly understood, especially in old-growth forests (Woods et al. 2012). Rooney et al. (2004) and Wiegmann and Waller (2006) observed that species composition of upland forest understories in the Upper Midwest have changed substantially in 50 years, with a decrease in native species diversity and an increase in exotic species. Maintaining biodiversity is a goal of forest managers (Barbier et al. 2008; Woods et al. 2012). Barbier et al. (2008) concluded that "future research is needed to gain a better understanding of the

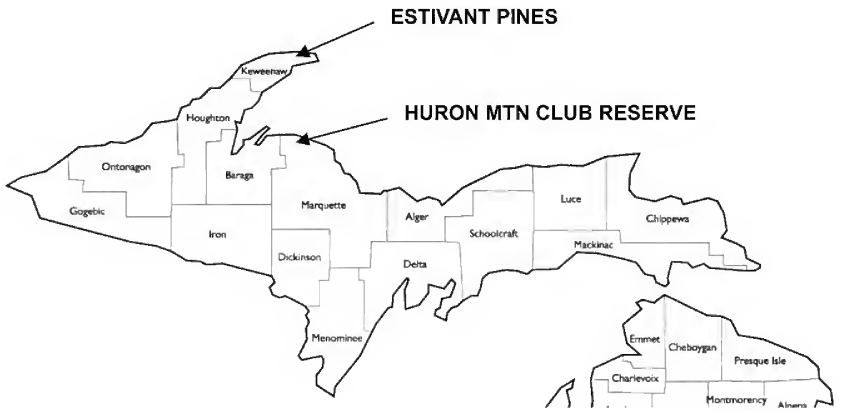

FIGURE 1. Location of Huron Mountain Club Reserve and Estivant Pines in Upper Michigan.

relationship between overstory and understory diversity." Wiegmann and Waller (2006) believed that "quantitative, long-term, retrospective studies are essential if we are to detect and respond to ecological change." Herbivory by abundant white-tailed deer (*Odecoileus virginianus*) is a major regional influence in both herb composition of the forest floor (Cote et al. 2004; Kraft et al. 2004; Wiegmann and Waller 2006) and regeneration success of tree seedlings (Rooney et al. 2002; Rooney and Waller 2003; Witt and Webster 2012). In an area of low deer densities, Woods et al. (2012) suggested changing canopy composition and understory competition as possible causes of an observed decline in fine-scale diversity in the forest floor of late-successional stands.

As part of a long-term study of *Pinus strobus* stands in Upper Michigan and northern Wisconsin (Riege 2011, 2012), I established large permanent plots in Michigan's Huron Mountain Club Reserve and Estivant Pines (Figure 1). These stands will be undergoing transition in future decades, since most of the *P. strobus* trees are large canopy emergents, and very few are saplings or seedlings. The plots will be utilized to investigate topics of current regional concern, such as effects on vegetation of deer herbivory, exotic species invasions, and climate change, as well as general successional dynamics. Most ground vegetation studies concentrate on herbs and shrubs, but exclude seedlings of tree species from the community analysis (but see Schiller and Mladenoff 2002, Frelich et al. 2003). However, since tree seedlings are an important part of the competitive array on the forest floor, they are included in the analysis presented here. In addition, tree seedlings are emphasized because differential regeneration and growth of tree species will ultimately determine the long-term composition of the forest.

This investigation of the ground vegetation of the permanent plots is a companion paper to that of Riege (2011) on tree and sapling demography of the two forests. This article (1) examines community composition of the forest floor

among these old-growth stands, particularly in relation to the overstory, and (2) presents reference data for future studies of vegetation dynamics of these forests.

MATERIALS AND METHODS

Study Areas

The Huron Mountain Club has maintained a 2500 ha reserve for over a century in Michigan's Huron Mountains that border Lake Superior (Figure 1). The reserve contains extensive forests of old-growth mesic *Tsuga canadensis*, *Acer saccharum*, and northern hardwoods, which have been the subject of several previous studies (Braun 1950; Woods 2000; Woods 2008; Marx and Walters 2008). Old-growth *Pinus strobus* stands are uncommon in the mesic forests of the Huron Mountains, though emergent pines are a component of many *T. canadensis*–northern hardwoods stands there. During 2007 and 2008, I established two adjacent permanent plots totaling 2.4 ha by Fisher Creek in the Huron Mountain Club Reserve, located within 46°51.4′–51.6′ N and 87°52.9′–53.1′W. The north plot (FCN = Fisher Creek North) covered 1.58 ha of *P. strobus–T. canadensis*–northern hardwoods forest (Table 1). The adjacent 0.82-ha south plot (FCS = Fisher Creek South) contained an atypical *P. strobus–Picea glauca–Acer rubrum* stand with a thick sapling understory of *A. saccharum* (Figure 2) that has been described by Thompson (1985), Simpson et al. (1990), and Riege (2011). Fahey (2011) reported that the oldest white pine among core samples at the Fisher Creek stands was about 210 years old. Plot maps are on file in reports to the Huron Mountain Wildlife Foundation (www.hmwf.org). Schwenner (2007) classified most of the soils in the FCS plot as belonging to the Evart-Pelkie-Sturgeon complex of deep, poorly drained, permeable soils that form in silty and sandy alluvium, and most of those in the FCN plot as belonging to the Kalkaska-Waiska complex of deep, well-drained, permeable soils on sandy outwash.

Estivant Pines, which contains the largest preserved tract of old-growth *Pinus strobus* in Michigan, is located in a 206 ha sanctuary of the Michigan Nature Association, south of Copper Harbor near the tip of the Keweenaw Peninsula (Figure 1). During 2010, I established a 0.78-ha permanent plot (EPU = Estivant Pines Upland) in an upland *P. strobus* stand known as Cathedral Grove (Figure 3) that followed the top of a broad ridge. A second 0.75 ha plot (EPG = Estivant Pines Gap) was established to the west on a lower plateau, separated from the EPU plot by a 20–30 m wide ravine. The EPG plot contained large gaps (0.03-0.06 ha) and a diversity of tree regeneration. Below the emergent pines at Estivant Pines, *Acer saccharum* and *Abies balsamea* were dominant (Table 1). The oldest *P. strobus* sampled in the plots by Fahey (2011) was about 260 years old. The Estivant Pines plots were located within 47°26.2′–26.4′ N and 87°52.8′–53.1′ W. Maps of the Estivant Pines plots are on

TABLE 1. Basal area, in m^2/ha, of tree species at the study plots at Huron Mountains (FCN and FCS) in 2011 and at Estivant Pines (EPU and EPG) in 2010. The acronyms of the study plots are defined in the text.

	FCN	FCS	EPU	EPG
Pinus strobus	14.4	29.2	25.0	5.5
Tsuga canadensis	12.8	0.9		
Acer saccharum	15.4	1.3	12.5	10.7
Acer rubrum	1.9	5.1	2.6	4.1
Quercus rubra			0.2	1.6
Betula alleghaniensis	6.1	0.6	1.9	2.4
Betula papyrifera	0.2		0.3	0.2
Picea glauca	0.9	5.6	0.4	0.5
Abies balsamea	0.6	0.4	8.2	6.1
Thuja occidentalis	0.9		3.3	2.9
Tilia americana	0.1			
Ostrya virginiana	0.2	0.0	0.0	0.3
Acer pensylvanicum	0.0	0.0		
Totals	**53.4**	**43.1**	**54.6**	**34.7**

FIGURE 2. Photograph of *Acer saccharum* sapling thicket in the FCS plot at Huron Mountain Club Reserve.

file in reports to the Michigan Nature Association (www.michigannature.org). Soils at both plots were classified by Tardy (2006) as Arcadian-Dishno-rock outcrop complex of well-drained, cobbly and very gravelly fine sandy loams.

All living stems greater than or equal to 5 cm DBH were measured in the Huron Mountain plots in 2011 and in the Estivant Pines plots in 2010, the same years that the ground transect studies described below were undertaken. Tree species dominance from these measurements is summarized in Table 1. In the same years, densities of small sapling (individuals of 1.0-4.9 cm diameter DBH) were determined by counting all saplings within 2 m of the midline of the transects (Table 2).

Methods

The presence by species of tree seedlings (defined for purposes of this study as individuals whose stems at DBH are less than 1 cm in diameter), shrubs, and herbs was recorded on August 1-3, 2010 at Estivant Pines and on June 21–24, 2011 at the Huron Mountain Club along marked transect lines that run across the plots, in continuous strips of 2 × 2 m quadrats. The percentage cover of the species was not estimated, but presence/absence data were tallied. This transect method was chosen to facilitate the measurement over time of the spread or contraction of ground species, as well as for efficiency in periodic monitoring of the permanent plots. The total number of quadrats was 326 in the FCN plot, 145 in the FCS plot, 156 in the EPU plot, and 196 in the EPG plot. Transect lines were spread out to cover all sections of the plots. Some transect locations in the FCN and EPG plots were chosen to pass through canopy gaps to monitor long-term changes within the gaps.

During subsequent field trips to the plots in 2012 and 2013, species that were difficult to identify in the quadrats were reexamined. Voucher specimens of these species were collected and deposited in the Northern Michigan University Herbarium (NM), where they were subsequently identified. Individuals of *Carex* could not always be identified to species in the field, hence are listed as "*Carex* spp." in Table 3. However, it was evident when more than one *Carex* species was present in a

FIGURE 3. Photograph of the EPU plot at Estivant Pines with large *Pinus strobus*, intermediate hardwoods, and *Thuja occidentalis–Abies balsamea* understory.

quadrat. Thus, for species richness data, the number of *Carex* species in each quadrat was recorded. *Carex* specimens submitted to NM from the Huron Mountain Club Reserve were identified as *C. gracillima, C. pedunculata,* and *C. arctata* and from Estivant Pines as *C. gracillima* and *C. communis*. In each of the plots other than EPU, there was one unidentified grass species in one of the quadrats.

For purposes of this study, the term "quadrat species richness" means the number of species found in a given quadrat. To determine if the mean quadrat species richness differed among the four

TABLE 2. Number of small saplings of each species per ha, based on transect samples, in the study plots at Huron Mountains (FCN and FCS) in 2011 and at Estivant Pines (EPU and EPG) in 2010. The acronyms of the study plots are defined in the text.

	FCN	FCS	EPU	EPG
Pinus strobus				128
Acer saccharum	169	1603	40	51
Acer rubrum		60	112	83
Quercus rubra			88	191
Betula alleghaniensis			48	153
Picea glauca	31		32	6
Abies balsamea			753	1595
Thuja occidentalis			577	198
Ostrya virginiana	180		8	32
Acer pensylvanicum	26	26		
Totals	406	1689	1130	2437

plots, quadrat species richness values in the plots were compared by the Bonferroni method after one-way ANOVA, with Statistix 9.0. software. Nomenclature follows Voss and Reznicek (2012) for seed plants and Reznicek, Voss, and Walters (2011) for ferns and fern allies. This paper lists only those species that were found in the quadrats during the sampling times. Thus, it does not constitute a complete flora of the stands. Wells and Thompson (1976) published a flora of the Huron Mountains, but a flora of Estivant Pines is not available.

RESULTS

Table 3 lists 57 ground cover species encountered in the quadrats. The only nonnative species was *Veronica officinalis*, which was present in small amounts at Estivant Pines. In the Huron Mountains, quadrat species richness was significantly greater in the FCN plot than in the FCS plot (Table 4). This was due to the greater frequency and diversity of tree seedlings in the FCN plot (Table 3); when tree seedlings are excluded, richness does not differ in the FCN and FCS plots. *Ostrya virginiana* and *Acer pensylvanicum* seedlings were much more common in the FCN plot than in the FCS plot. *Acer saccharum* seedlings were the most frequent species in the FCN plot. *Streptopus lanceolatus*, *Maianthemum canadense*, and *Trientalis borealis* were the most common herbs (Table 3). *Dryopteris carthusiana* was the most common species in the FCS plot, where *A. saccharum*, *M. canadense*, and *T. borealis* also occurred in the majority of quadrats. Among the major differences between the two Huron Mountains plots was the much greater presence of *Streptopus lanceolatus* and the lycopods *Dendrolycopodium dendroides* and *Huperzia lucidula* in FCN. In contrast, the FCS plot contained more individuals of *Osmorhiza claytonii*, *Viola blanda*, and *V. cucullata*.

The Estivant Pines plots were considerably less rich in species than were the Huron Mountain plots (Table 4). Among the former, the EPG plot was greater in quadrat species richness than the EPU plot, which might be attributed to the presence of canopy gaps in the EPG plot. Tree seedlings contributed the major component of the species richness in both of the Estivant Pines plots, which contrasted with tree seedlings comprising less than one-third the richness in the Huron Mountains plots. In the EPU plot, ground cover was dominated by *Thuja occidentalis* seedlings and was strikingly depauperate in species of herbs (Tables 3 and 4). *Maianthemum canadense* was the most common herb in the EPU plot, but occurred in only 21% of the quadrats (Table 3). Most tree species were more common in EPG than in EPU. Graminoid species were more abundant in EPG, as were the shrubs *Corylus cornuta* and *Rubus parviflorus* (Table 3).

To investigate the dominant role that seedlings of *Thuja occidentalis* seemed to play in the ground vegetation of Estivant Pines, the species richness of the quadrats in which *T. occidentalis* was present was compared with the quadrats in which it was absent. Quadrats in which *T. occidentalis* was present had significantly ($p < 0.05$, *t*-test) fewer species (2.8 ± 0.1 SE) than those without (3.3 ± 0.2 SE).

TABLE 3. Frequencies of ground species in the study plots, as measured by the percentage of quadrats in which that species is present. The acronyms of the study plots are defined in the text.

	FCN	FCS	EPU	EPG
Tree Seedlings				
Abies balsamea L.	2.5	2.1	14.1	32.7
Acer pensylvanicum L.	27.0	13.1		
Acer rubrum L.	23.3	22.1	25.0	23.0
Acer saccharum Marshall	87.7	77.2	20.5	55.6
Acer spicatum Lam.			1.3	1.1
Betula alleghaniensis Britton		0.7	0.6	3.1
Ostrya virginiana (Mill.) K. Koch	24.5	7.6		5.1
Picea glauca (Moench) Voss	3.1	2.8	3.2	9.2
Pinus strobus L.	1.5	2.1	1.3	11.7
Quercus rubra L.	1.2		16.0	30.1
Thuja occidentalis L.			70.5	33.7
Tilia americana L.	0.6			
Tsuga canadensis L.	3.4	2.1		
Other Species				
Anemone quinquefolia L.	3.4			
Aralia nudicaulis L.	14.7	22.1	7.7	2.0
Athyrium felix-femina L.	1.2	0.7		
Carex spp	34.4	31.0	2.6	17.9
Chimaphila umbellata L.			5.8	4.1
Cinna latifolia (Goepp.) Griseb.	0.6	13.8		
Clintonia borealis (Aiton) Raf	11.3	4.8	1.9	
Coptis trifolia (L.) Salisb.	2.5	3.4		
Cornus canadensis L.	0.3	4.1		
Cornus rugosa Lam.				1.0
Corylus cornuta Marshall	2.5	2.8	10.3	28.1
Dendrolycopodium dendroides (Michx.) A. Haines	35.3			
Dryopteris carthusiana (Vill.) H.P.Fuchs	46.6	93.6	5.6	0.6
Equisetum sylvaticum L.		0.7		
Eurybia macrophylla (L.) Cass	7.1	1.4		
Galium triflorum Michx.	0.6	4.1		
Gaylussacia baccata (Wangenh.) K. Koch				1.0
Goodyera oblongifolia Raf.	0.3		4.5	5.6
Gymnocarpium dryopteris (L.) Newm.	0.9			
Hepatica americana (DC) Ker Gawl.	2.5		0.6	0.5
Huperzia lucidula (Michx.) R. Trevis	13.8	2.8		
Impatiens pallida Nutt.	0.6			
Linnaea borealis L.	0.3			
Lonicera canadensis Marshall	20.9	9.7	6.4	10.7
Maianthemum canadense Desf.	54.9	79.3	21.2	17.3
Mitchella repens L.	8.6			6.1
Onoclea sensibilis L.		1.4		
Oryzopsis asperifolia Michx.	22.1	5.5		15.3
Osmorhiza claytonii (Michx.) C.B.Clarke	7.4	21.4		
Polygonatum pubescens (Willd.) Pursh	1.2			
Pteridium aquilinum (L.) Kuhn	8.3	2.8	4.1	1.9
Pyrola elliptica Nutt.	3.1	0.7		
Ribes lacustre (Pers.) Poir.		0.7		0.5
Rubus parviflorus Nutt.	1.2	3.4	4.5	26.5
Sambucus racemosa L.		0.7		
Scutellaria lateriflora L.	0.6			

TABLE 3. Continued.

	FCN	FCS	EPU	EPG
Sorbus americana Marshall			1.9	1.5
Streptopus lanceolatus (Aiton) Reveal	56.4	6.9		
Trientalis borealis Raf.	50.6	52.4	1.0	12.8
Trillium cernuum L.		2.8		
unidentified grass species	0.3	0.7		0.5
Veronica officinalis L.			1.9	2.6
Viola blanda Willd.	3.7	24.8		
Viola cucullata Aiton		5.5		
Viola pubescens Aiton	3.4			

DISCUSSION

The ground species composition of the Huron Mountains plots was typical of regional *Tsuga canadensis–Acer saccharum* forests (Curtis 1959; Willis and Coffman 1975; Woods et al. 2012). The tree composition of the FCN plot (Table 1) fits descriptions of a "classic" *Tsuga canadensis–Pinus strobus*–northern hardwoods forest (Nichols 1935; Braun 1950; Curtis 1959). A *Pinus strobus–Picea glauca–Acer rubrum* stand, as found in the FCS plot, has not generally been recognized as a common forest association (Eyre 1980; Wendel and Smith 1990). Although the FCS plot contained a flora similar to that of the FCN plot, the differences in the ground community indicated that the FCS plot was slightly moister or more wet-mesic than the mesic FCN plot when compared to regional community classifications (Curtis 1959; Willis and Coffman 1975; Kotar et al. 2002), as determined by the greater abundance in the FCS plot of species such as *Osmorhiza claytonii*, *Viola blanda*, *V. cucullata*, and *Dryopteris carthusiana*. (Table 3). Classification as a wet-mesic stand, however, is somewhat counter to the dominance in the FCS plot by *Pinus strobus*, which is more often associated with dry-mesic sites (Curtis 1959; Wendel and Smith 1990). *Pinus strobus* is also known, however, to occupy wetter sites with poor drainage and less competition (Abrams 2001). The FCS plot lay slightly lower in eleva-

TABLE 4. Species richness of ground plants in each study plot, as measured by the mean number of species per quadrat ± standard error. Column a is calculated by including all species present in all quadrats. Column b is calculated by including all species except tree seedlings in all quadrats. Different superscript letters within each column indicate that the mean number of species per quadrat differs by $p < 0.01$ by Bonferroni comparison after one-way ANOVA.

	Species Richness	
Plot	(a) Tree seedlings included	(b) Tree seedlings excluded
FCN	6.0 ± 0.1^{a}	4.1 ± 0.1^{a}
FCS	5.3 ± 0.2^{b}	3.9 ± 0.1^{a}
EPU	2.3 ± 0.2^{c}	0.7 ± 0.1^{b}
EPG	3.7 ± 0.1^{d}	1.6 ± 0.1^{c}

tion than the FCN plot and is adjacent to Fisher Creek, which is consistent with its more wet-mesic nature. During the autumn of 2011, after the June 2011 survey of ground vegetation reported in this paper was carried out, I noticed that beaver had started to cut saplings in the FCS plot that caused flooding at the edges of the plot. Perhaps past flooding episodes have influenced the evolution of vegetation in the FCS plot.

The *Pinus strobus*–northern hardwoods forest at Estivant Pines differed from the Huron Mountains stands by the absence of *Tsuga canadensis* and the presence of a dense *Abies balsamea–Thuja occidentalis* subcanopy (Tables 1 and 2). The Estivant Pines plots have an essentially three-layered canopy in which *Pinus strobus* is emergent, *Acer saccharum* dominates the middle layer, and *Abies balsamea* and *Thuja occidentalis* are dominant below (Figure 3). The ground cover at Estivant Pines was considerably more barren and less diverse than at the Huron Mountains stand (Tables 3 and 4). Community composition at Estivant Pines indicated a dry-mesic site, with occupation by species such as *Quercus rubra*, *Chimaphila umbellata*, *Goodyera oblongifolia*, and *P. strobus* (Curtis 1959; Maycock 1961; Chadde 2013). A dry-mesic classification is appropriate for the well-drained, sandy loam soils. The most frequent ground-cover species, *Thuja occidentalis*, is usually associated with wet-mesic or wet stands in the region (Maycock and Curtis 1960; Johnston 1990), but is also known to have a bimodal distribution in both wet and dry sites (Hofmeyer et al. 2009). Thickets of *Abies balsamea* saplings and, to a lesser extent, *Thuja occidentalis*, dominated the subcanopy of much of the Estivant Pine plots (Table 2). Maycock (1961) reported that boreal stands of *Abies balsamea–Picea glauca* become more common at the northern tip of the Keweenaw Peninsula, as presumably do boreal components of mixed stands. He also found that *Acer saccharum* was common in Keweenaw boreal stands and tended to increase in importance over time. Maycock reported *Thuja occidentalis* to be a common associate in these forests, especially in wet-mesic stands. Dense stands of *T. occidentalis* have been reported to inhibit colonization by other species (de Blois and Bouchard 1995). At Estivant Pines, species richness declined in quadrats where *T. occidentalis* seedlings were present in the ground cover. *T. occidentalis* can persist for many decades in the form of suppressed understory plants that spread by vegetative reproduction (Johnston 1990; Hofmeyer et al. 2009). *Thuja occidentalis* has been shown to produce allelopathic compounds that inhibit herb germination (Oster et al. 1990).

Ground species richness has been reported to decrease as dominance by *Tsuga canadensis* in a forest increases (Auclair and Goff 1971, Barbier et al. 2008, Ellum et al. 2010). In contrast to this trend, ground species richness was highest in the FCN plot (Table 4), the plot in which *T. canadensis* is a major component (Table 1). In the Dukes Research Area in Marquette County, Michigan, Woods et al. (2012) also found species richness to be higher in *Tsuga*-dominated forests than in other upland forests. The mean species per quadrat values at the Huron Mountains plots were similar to those reported in mature Upper Michigan *Tsuga canadensis–Acer saccharum* forests by Scheller and Mladenoff (2002), who used 2 m × 2 m quadrats and included tree seedlings, as in this study. However, the low species richness at Estivant Pines contrasted with May-

cock's (1961) finding that the herb layer of the Keweenaw Peninsula boreal–maple forests was relatively species diverse. Barbier et al. (2008) noted that herb diversity can be depressed by a developed subcanopy, as in the *Abies balsamea–Thuja occidentalis* thickets in the Estivant Pines plots.

Rooney et al. (2004) and Wiegmann and Waller (2006) reported changes in the understory vegetation of 62 upland forest stands in northern Wisconsin and Upper Michigan that had been sampled more than 50 years previously by Curtis (1959) and his students. Wiegmann and Waller (2006) identified 21 "winner" species that significantly increased in frequency and 21 "losers" that decreased. An increase in density of exotic species was also discovered. They concluded that tolerance to deer herbivory was a key factor in determining the winner species and that deer herbivory also influenced the decline in the ratio of native to nonnative species. Species in the Huron Mountains and Estivant Pines plots included 13 of the Wiegmann and Waller loser species and 10 of the winners. The abundance of the grazer-prone loser species, such as *Streptopus lanceolatus, Aralia nudicaulis*, and *Clintonia borealis*, may indicate that deer herbivory is relatively low in the Huron Mountains stands. Deer densities in 2009 in the Upper Peninsula were mapped by the Michigan DNR (2010) to be lowest in areas near Lake Superior and higher near the Wisconsin border. *Thuja occidentalis* is heavily browsed in the region, where deer have inhibited its regeneration in many stands (Rooney et al. 2002). The abundance of *T. occidentalis* was indicative of low browsing pressure at Estivant Pines. On the other hand in the Huron Mountains plots, Riege (unpublished data) recorded sufficient browsing on *Tsuga canadensis* seedlings to suggest that it was a major factor in the absence of *T. canadensis* in the small sapling cohort. Regeneration of *T. canadensis* suffers greatly from browsing in the region (Anderson and Loucks 1979; Rooney and Waller 2003; Witt and Webster 2010). As noted earlier, only one exotic species was recorded in the quadrats—*Veronica officinalis* at Estivant Pines. Both the Huron Mountains and the Estivant Pines study sites are located deep within forest preserves, though a well-traveled hiking trail crosses the Estivant Pines plots.

The fate of tree seedlings will determine the future of the forest in the long run. In the transect samples at the Huron Mountains stand, only five species of small saplings were found, although 11 species were present as seedlings (Tables 2 and 3). Along with herbivory (as seen in *Tsuga canadensis*), shading may have been a factor in this reduction. The *Tsuga canadensis–Acer saccharum* cover in the FCN plot and the *A. saccharum* sapling thicket in the FCS plot likely inhibited shade-intolerant seedlings. In contrast to the Huron Mountains plots, most of the species present in the Estivant Pines plots as seedlings were also represented as small saplings (Tables 2 and 3). Canopy gaps were a likely factor in survival at the EPG plot. Interestingly, the dense subcanopies of *Abies* and *Thuja* at Estivant Pines did not exclude the other species from reaching the sapling stage. *Acer saccharum* seedlings were ubiquitous in the Huron Mountains plots and abundant in the EPG plot (Table 3). Adventitious *A. saccharum* seedlings may survive years in a suppressed state (Woods 2008). In contrast, at the EPU plot, *A. saccharum* seedlings were present in only one-fifth of the quadrats, even though

A. saccharum trees were common throughout the plot. Perhaps regeneration of *A. saccharum* was deterred by the cover of *Thuja occidentalis*.

Although old-growth *Pinus strobus* trees were abundant in these stands, *P. strobus* seedlings were rare at both sites, and saplings appeared only in the transects at the EPG plot (Tables 2 and 3). This probably reflected its intolerance to dense shade (Wendel and Smith 1990). Very slow growth of *P. strobus* seedlings, with episodes of browse back, have been noted over a 5-year study in the Huron Mountains and Estivant Pines plots (Riege, unpublished data). With the possible exception of the EPG plot, the outlook for long-term reproduction of *P. strobus* in the forests is dim. However, the findings of Riege (2012) caution against using present demography to project into the future. He found recent surges in *P. strobus* reproduction in Wisconsin forests that were not indicated by demographic studies that were reported decades earlier in these forests.

The most important results of this project on dynamics of old-growth forests will be in the future. Long-term studies of the ground vegetation will permit the investigation of general late-successional dynamics. For example, will fine-scale species richness of ground plants in undisturbed forests decrease over time, as Woods et al. (2012) reported in an Upper Michigan late-successional stand? The Huron Mountains and Estivant Pines plots also provide an opportunity to address specific topics, such as effects of beaver cutting on ground vegetation of the FCS plot. Deer browsing effects will be examined in FCN as the control plot for a nearby 2 ha exclosure. Potential suppression of ground cover by *Thuja occidentalis* will be followed at the EPU plot. Future effects of invasive species or climate change on the forest floor can be examined. Results on survival and growth of white pine seedlings within the ground communities will be synthesized with those of sapling and canopy stages to provide insights to managers who wish to maintain or restore white pine in regional forests. The fate of forests is unpredictable from present composition (Bakker et al. 1996; Riege 2012).

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ASSESSING A RECONCILIATION ECOLOGY APPROACH TO SUBURBAN LANDSCAPING: BIODIVERSITY ON A COLLEGE CAMPUS

Christopher Bouma, Emily Huizenga, and David Warners[1]

Department of Biology
Calvin College
3201 Burton Street SE
Grand Rapids, Michigan 49546

ABSTRACT

As urban expansion continues to replace natural areas with non-native landscaping, native vegetation becomes increasingly scarce, and higher trophic levels that depend on native plant species decline, contributing to an overall erosion of biodiversity. The question addressed by this study is: Can reintroducing small patches of native habitat into suburban landscapes result in the subsequent recruitment of higher trophic levels of native biodiversity? We assessed plant, insect, bird, and small mammal biodiversity in four different habitats on the main campus of Calvin College in Grand Rapids, Michigan: open lawn, treed lawn, restored woodland plantings, and intact forest habitats. In four replicates of each area we evaluated plant, insect and small mammal diversity. We found that the restored woodland plantings had the highest diversity in each of the taxonomic groups. The lawn and treed lawn areas generally supported the lowest diversity, and the intact forest sites had intermediate diversity. We conclude that even small, relatively isolated islands of native habitat in a broader suburban landscape do have the capacity to increase abundance of higher trophic levels of native biodiversity.

KEYWORDS: biodiversity, restoration ecology, trophic interactions, habitat fragmentation, island biogeography

INTRODUCTION

Biodiversity continues to decline globally as habitat loss and invasive species advance. While these two drivers of biodiversity loss have been well documented (Pimentel et al. 2004; Pimm et al. 1995; Vitousek et al. 1997), a more subtle aspect to the erosion of diversity in North America is the *way* we continue to develop our urban areas (Rosenzweig 2003). The traditional model of urban development essentially pushes the natural landscape out of the way, replacing it with a simplified topography and greatly reduced habitat diversity. Mostly non-native trees, shrubs, and turf grasses are introduced to accompany the newly built environment. The prevailing dualistic and misguided mindset that results is that 'nature' exists somewhere outside urban and suburban areas of human settlement and that the presence of human beings requires the sacrifice of native biodiversity.

Some non-native species planted in urban areas spread and become invasive

[1] Author for correspondence (dwarners@calvin.edu)

in natural areas, which results in a diminished abundance of native plants and the associated loss of higher levels of native diversity dependent on native plant species. Non-native plants that are not aggressively invasive may still adversely affect biodiversity by being unpalatable to herbivores and unattractive to pollinators (Southwood et al. 1982; Tallamy 2004). Horticultural species that emerge through artificial selection (intentional or otherwise) can be more resilient to environmental stresses than native species, thereby pre-adapting them to a long-term presence in natural areas once they have been successfully dispersed (Torchin et al. 2003). Therefore, many non-native species originally introduced as ornamental plants have advanced into natural areas, either as harmful invasives or as innocuous waifs, contributing little or no benefit to higher trophic levels of biodiversity (Tallamy 2004). Furthermore, any time non-native plants are used instead of native species in landscaping, their presence (regardless of how invasive or persistent they may be) incurs a lost opportunity cost for the local biotic community.

Restoration ecology is one approach to address biodiversity loss, but this approach focuses on healing degraded ecosystems in an attempt to re-create more natural, and ecologically more functional habitats. While this is a worthwhile endeavor when appropriate, it is very expensive to do restoration well, especially on a large scale. In addition, most landscapes that have been altered from their original natural state are currently functioning to support human life and are not eligible even to be considered for restoration efforts (Hilderbrand et al. 2005; Hobbs et al. 2011).

Recent work in the areas of sustainability studies and urban ecology has helped establish a newly emerging paradigm for abating species loss—reconciliation ecology (Rosenzweig 2003; Pickett et al. 2008; Heffner and Warners 2011; Warners et al. 2014). Reconciliation ecology has been described as the practice of reintroducing native plants into urban and suburban environments to benefit native species (Rosenzweig 2003). The expectation is that these native plants will provide resources for insects and other species at higher trophic levels, thereby leading to an overall increase in native biodiversity specifically and strategically *within* the very places where high densities of human beings live, work, and recreate.

On the campus of Calvin College, in Grand Rapids, Michigan, this concept has been actualized in the form of four restored habitats on the main part of campus. Historically, this property was dominated by deciduous forests—oak and hickory on the better-drained, sandier soils, and beech and maple on the heavier clay soils. But the property was converted from forest to farmland around the turn of the twentieth century and later into areas of lawn interspersed with remnant woodlots and fencerows when the campus was created in 1957. In 2007, some areas of lawn were transformed into restored natural woodlands as mitigation for the loss of a mature oak–hickory woodlot on the campus. These restored areas were initiated with young trees 5–10 years old, some shrubs and herbaceous transplants, and locally collected seed mixes that were spread throughout each site. Species chosen for the restoration sites are all typically found in natural oak remnants in western Michigan and were likely present on the campus

property prior to the original conversion to farmland. Local genotypes were exclusively used in these restoration plantings.

Although it is obvious that the restoration areas contain greater plant biodiversity than the lawns they replaced, a detailed evaluation of the vegetation that exists in these habitats had not been done since the original plantings were established. Therefore it was not known how much of the present plant diversity in these areas is due to desired native species and how much is contributed by unwanted non-native weeds. The context of multiple habitats existing within one campus provides a valuable opportunity to evaluate the potential of these restored areas to recruit higher trophic levels of biodiversity, a claim frequently made by restorationists yet seldom quantified.

Our approach was to sample the restored areas for plants, insects, birds, and small mammals and compare these data with identical sampling in three other campus habitats: lawn, treed lawn, and forest. If these areas of restored habitat yield greater biodiversity in higher trophic levels, it would indicate that even small islands of native landscapes can have a significant ecological benefit. However, principles of island biogeography would suggest a rapid diminishing return with smaller and smaller habitats, raising the question of whether benefits to higher trophic levels can be achieved with such small 'islands' of native habitat within a sea of suburban development. The hypothesis we tested has two parts: 1) that the restored and forested areas will each support significantly greater amounts of biodiversity than either the lawn or the treed lawn areas; and 2) that the restored and forested habitats will each support similar levels of native biodiversity.

MATERIALS AND METHODS

Location

The Calvin College main campus is located in the southeastern portion of Grand Rapids, Michigan, and is bordered on the south and west by suburban residential neighborhoods. On the east side of campus is a college-owned 90-acre preserve that includes a mature woodlot surrounded by abandoned agricultural fields. Beyond this preserve to the east is a business corridor and interstate highway. To the north of the campus there is a mix of larger parceled residential lots and some scattered natural areas associated with the Reeds Lake drainage basin. The campus itself is dominated by lawn and treed lawn landscapes, as is typical of human-dominated suburban areas in the Midwest. A few small undeveloped forested remnants are interspersed within the campus landscape, as are the four restoration sites described above.

We collected data from four replicated 10 m × 10 m plots representing each of the four habitat types: lawn, treed lawn, restored woodland, and forested areas (16 plots in total). We defined "lawn areas" as open turf grass that is being actively maintained, and "treed lawns" as open turf grass maintained in the same way but containing at least one tree greater than 13 cm diameter at breast height and another tree of equal or greater size within 10 m of that tree. The forested areas used in this study were defined as current mid- to late-successional forest with no lawn and no maintenance other than the occasional removal of potentially dangerous snags and branches. The four restored areas are dispersed broadly across the campus and range in size from approximately 500 m^2 to 2000 m^2. They were all installed with a similar mix of native trees, shrubs, and herbaceous species. All 16 sites were selectively located to be at least 100 m away from each other (Figure 1).

Once these areas were identified, each site was mapped into as many 10 m ×10 m plots as they could contain. The plots were numbered, and one plot from each site was randomly selected for data collection. Plots were corner-marked with flags in the restored woodland and forested areas, while

FIGURE 1. Aerial view of Calvin College in Grand Rapids, Michigan, showing 16 study sites (4 replicates of each habitat type) as they are distributed across Calvin's campus.

in-ground markers were used for lawn and treed lawn areas. All plots were located at least 3 m from the edge of their respective habitats to minimize possible edge interactions.

Plant Inventory

To assess plant diversity, we randomly selected five 1 m^2 quadrats within each of the sixteen 10 m × 10 m plots. Within these five quadrats, we inventoried each species that was present and the relative percentage cover of each species (for a complete plant species list for all study sites please contact the authors). The sampling was carried out in all 16 sites during a three-week period in June 2011. From these data we were able to compare average number of species, relative abundance, and ratio of native to non-native species within and between habitat types (although these vegetative data will not be specifically reported in this paper).

During the fall of 2011 we also did a more comprehensive vegetation analysis in order to perform a Floristic Quality Assessment (FQA) of each of the 16 sites by recording all species encountered as we walked line transects at 2 meter intervals through each plot. This was first done in one direction and then in the perpendicular direction to ensure maximum coverage. From these lists we calculated a Floristic Quality Index (FQI) for each site using the coefficient of conservatism of each species, as assigned by the Michigan DNR (Hermann et al. 2001). A one-way ANOVA test was performed to compare mean FQI values among the different habitat types along with a Tukey-Kramer post hoc test to evaluate mean differences.

Insect Biodiversity

We collected insects by sweep netting both in summer and fall, covering all 16 sites at four different times—two in the summer (June 29–30 and July 6–13) and two in the fall (September 25 and October 8). On these occasions, we systematically swept through the tops of the herbaceous vegetative cover of each 10 m × 10 m plot. Insects trapped in the net were transferred to a jar of alcohol and later sorted in the laboratory. Relative abundance and length of each insect were recorded and a Shannon diversity index was generated for each habitat (Shannon and Weaver 1949; Magurran

1988). We tested the mean values by habitat with a one-way ANOVA and Tukey-Kramer post-hoc test.

Bird Survey

To evaluate the frequency of bird visitation and use at our sites we conducted a bird survey at all 16 sites. The number and species of birds were observed during a 15-minute period at each site on four days in the spring of 2012 (April 21 and 29, May 3 and 17). The order in which these sites were visited was randomized to control for time of day as a potentially confounding factor. Birds that flew over the sites were not included, because direct use of the sites by the birds was the desired measurement. A Shannon diversity index was also generated for the bird data and a one-way ANOVA and Tukey-Kramer post hoc test was used to assess differences among the habitats.

Small Mammal Trapping

To evaluate the distribution of small mammals among different habitat types, we conducted a small scale catch and release survey. We placed two Sherman traps in each habitat on July 20, 21, and 26, and August 10, 2011. The traps were baited with oatmeal, sunflower hearts, peanut butter, and a protein supplement and also contained a small wad of polyester fiberfill to guard against hypothermia. Two traps were set approximately 3 m away from each other in the middle of each 10 m × 10 m plot. The traps were set just before sunset in order to minimize the possibility of human interference. We checked all the traps before dawn the following morning and recorded species, sex, hind foot length, tail length, total body length and ear length for each individual captured. The tails were then marked with permanent marker for future identification. This procedure was done at all 16 test sites every time the survey was performed, resulting in a total of 128 trap-nights (16 test sites × 2 traps per site × 4 nights = 128 trap-nights).

RESULTS

Vegetation

Floristic Quality Assessment (FQA) is an evaluation of the floristic and natural significance of a given area based on native plant diversity (Herman et al. 2001). This significance is expressed in a calculated Floristic Quality Index (FQI), based on the mean coefficient of conservatism and the square root of the number of native species present. Since none of our lawn sites contained any native plants, we have no FQI to report for the lawn sites. The FQI of the restored woodland habitat was significantly greater than it was for either the forested habitat or the treed lawn (Figure 2). Although the forested habitat had a higher FQI than the treed lawn, this difference was not statistically significant ($0.05 < p < 0.10$). The percentage of native species in the forested and restored woodland sites was almost identical at slightly above 80%. The treed lawn habitat had a significantly lower native species component (22%), most of which was due to the presence of overstory trees, with relictual vegetation sometimes growing at the bases of the trees.

Insects

The total average length of the insects from each site was calculated by taking an average length of all individuals of all taxa collected in a site. Four such values were generated for each habitat type, the total averages of which are re-

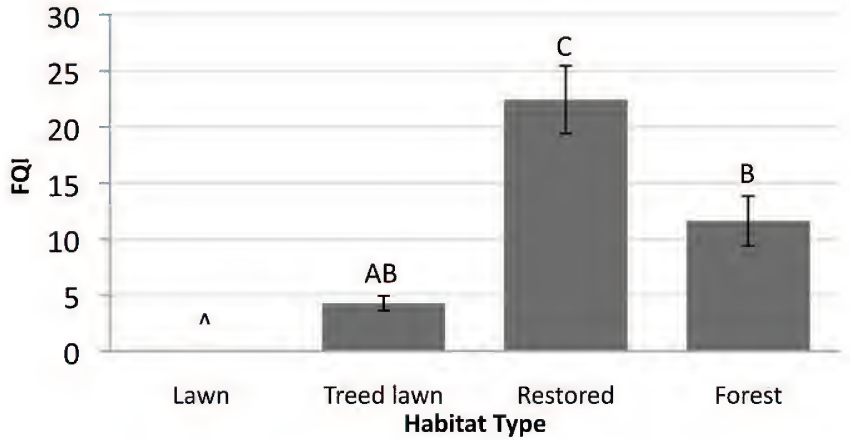

FIGURE 2. Average FQI for different habitat types. Bars not sharing the same letter are significantly different (One-way ANOVA, p<.05, n=4 for each habitat type). Error bars represent one standard error about the mean.

ported in Figure 3. The restored area was shown to have the highest average length ($p < 0.0001$), indicating that the largest insects are found there. The insects collected in the lawn and treed lawn sites had the lowest average length, and there was no significant difference between the averages calculated from

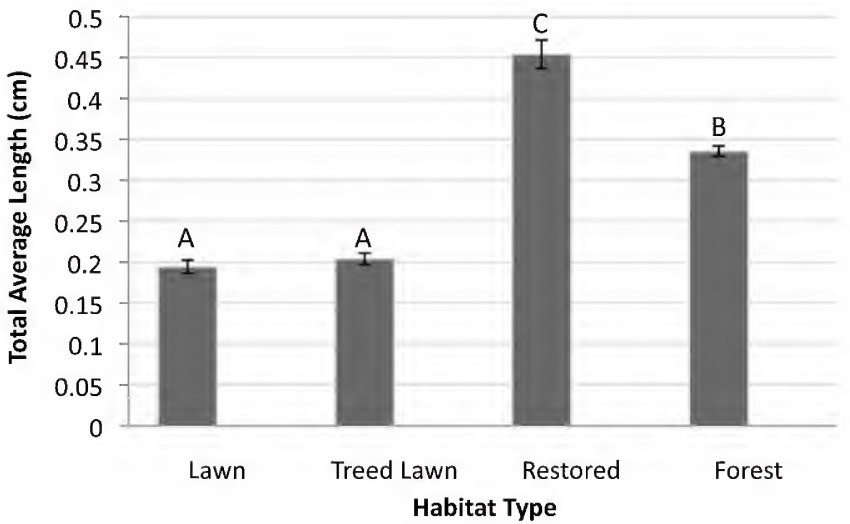

FIGURE 3. Total average length of insects in different habitat types. Bars that do not share the same letter are significantly different (One-way ANOVA, p<.05, n=4). Error bars represent one standard error about the mean.

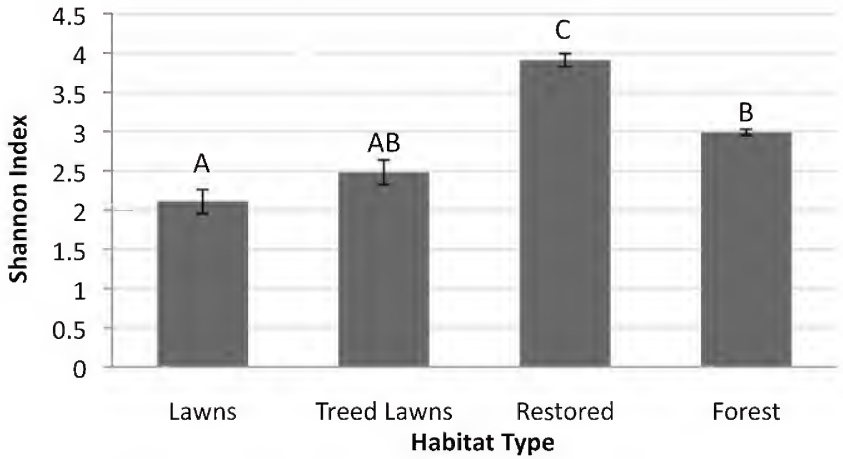

FIGURE 4. Average Shannon Index of insects for each habitat type. Bars that do not share the same letter are significantly different (One-way ANOVA, $p<.05$, $n=4$). Error bars represent one standard error about the mean.

these two habitat types. The insects collected in the forested sites had a higher average length than those from the lawn and treed lawn sites, but lower than that calculated for the insects in the restored woodland areas.

We calculated a Shannon index to quantitatively assess the richness and evenness in the diversity of insects in the different habitat types. Data collected from restored woodland habitats yielded a Shannon index of 3.67, which is significantly higher than that calculated for all the other sites ($p < 0.0001$) (Figure 4). The lawn and treed lawn sites have the lowest values, and they are not significantly different from each other. The forest habitat had an intermediate Shannon index, being significantly higher than the lawn areas, and significantly lower than the restored habitat, but not different statistically from the treed lawn.

Bird Survey

We took an average of the Shannon indices of the four days of bird watching for each site, and then averaged those values within each habitat type. All of the average Shannon indices for each habitat type were less than 1, ranging from 0.82 for the restored areas to 0.04 for the lawns (Figure 5). The Shannon index for the restored woodland was significantly different from that for the lawn ($p = 0.017$), but was not statistically different from that for any other site.

Small Mammals

We successfully trapped small mammals only in the restored woodland and forest sites. Although this part of our study was less extensive than the vegetation and insect sampling, in the 64 trap-nights for the lawn and treed lawn sites,

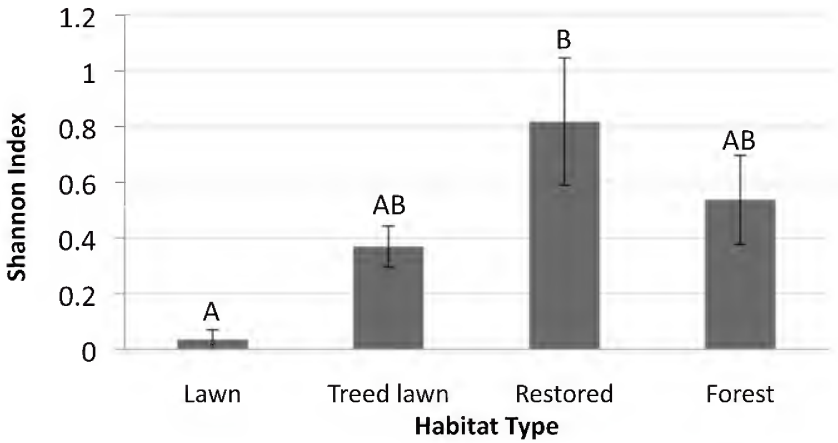

FIGURE 5. Total average Shannon index of birds in different habitat types. Bars that do not share the same letter are significantly different (One-way ANOVA, $p<.05$, $n=4$). Error bars represent one standard error about the mean.

TABLE 1. Inventory of small mammals trapped in Restored Woodland and Forest habitats (32 trap-nights per habitat). No small mammals were trapped in the lawn or the treed lawn habitat types.

	Habitat Type	
Species (common name)	Restored Forest	
Sorex cinereus (Masked shrew)	2	1
Peromyscus leucopus (White-footed mouse)	7	4
Peromyscus maniculatus (Deer mouse)	8	3
Microtus pennsylvanicus (Meadow vole)	3	0
Zapus hudsonius (Meadow jumping mouse)	0	5
Totals	**20**	**13**

we never caught a single animal. By contrast, in the restored woodland sites, we captured 20 small mammals of four different species in the 32 trap-nights, and in the forested sites we captured 13 small mammals of four different species (Table 1). The traps in the treed lawn sites sometimes showed signs of tampering (which could have been done by larger mammals, such as squirrels or raccoons), but, as noted, no small mammals were ever caught in these traps.

DISCUSSION

This study evaluates the relative capacity of restored natural habitats (on the scale of approximately 1000 m^2) located within the context of suburban landscaping to support higher levels of native biodiversity. The data we collected support the hypothesis that both the restored woodland and forested areas will

have greater biodiversity than either the lawn or the treed lawn areas. However, since most of our measures of biodiversity were highest in the restored woodland areas, we did not find support for our second hypothesis that restored and forested areas will support similar levels of native biodiversity.

The highest Floristic Quality Index (FQI) values were recorded from the restored woodland habitats, which had an average FQI value of 22.4 (Figure 2). Somewhat surprisingly, this value was nearly twice the mean FQI for the forested sites, which was 11.6. However, the restored woodland habitats had been planted only four years earlier and have been minimally maintained with occasional non-native removals and native species introductions. Because of the recent establishment of these areas, they support many young trees, a relatively high diversity of herbaceous perennials, and very little dense shade (Figure 6). The restored woodland sites are therefore similar to woodland edges, where both sun-loving and shade-tolerant plants can coexist (thereby elevating biodiversity) (Huston 1979; Leach and Givnish 1996). Furthermore, the forested sites are all relatively small (3,000–5,000 m^2), and, although they do provide dense canopy shade, they do not appear to be large enough or protected enough to support many of the more sensitive forest understory and ground-level species. Therefore, the biodiversity found in our campus forest sites is lower than that supported in similarly mature but larger tracts of forest in the vicinity. Yet based solely on the plants that are present in these sites, the Floristic Quality Assessment indicates that the restored areas represent the highest natural quality among these four habitat types.

By contrast, the lawn areas had an FQI of 0, because there were no native species found in any of these sites. The lawns are all actively managed and heavily dominated by Kentucky bluegrass (*Poa pratensis* L.) and some less abundant turf grass species, mostly because of consistent applications of broad-leaf herbicides. The treed lawn habitats had a higher average FQI (4.2) than the lawn habitats, both because of the presence of trees (most of which are native) and because some native herbaceous plants were found at the base of the trees, where they are able to avoid mowing and (apparently) herbicide application.

Insects are major pollinators and herbivores in terrestrial ecosystems, and they are the major food item for larger invertebrates, birds, and some small

FIGURE 6. Photograph of one of the restored woodland sites on Calvin's campus (van Reken Residence Hall).

mammals (Tallamy 2004). Other insects are vital components of the decomposing community. In short, insects are a major contributing element of a healthy ecosystem. Furthermore, several studies have shown that insects are associated with host-specific plants with which they co-evolve (Bernays and Graham 1988; Burghardt et al. 2008), underscoring the importance of native plant diversity for supporting native insect diversity.

This relationship is supported by the data we collected (Figures 3 and 4). The highest Shannon index for insects was calculated for the restored woodland areas (Figure 4). This pattern further supports our conclusion that the restored areas harbor the greatest ecological complexity. We found lawn areas, which had the lowest Shannon index, to be heavily dominated by only a few small-sized insect species, reflecting lower ecological complexity (Lawton et al. 1998). The treed lawn and wooded areas were not statistically different, which was surprising. Yet, in some of the wooded areas there was little to no ground cover, providing limited food sources for herbivorous insects. We suspect there are likely insects undetected by our sweep netting methods that reside in the soil, the bark of trees, and in the canopy that would increase the Shannon index value in the three habitat types that included trees.

Insect size diversity was also consistent with the plant data. Figure 3 shows the total average length of insects found in the four habitat types, with the largest value (0.45 cm) occurring in the restored areas. By contrast, average insect length in the lawn sites was 0.19 cm, significantly lower than that of the restored woodland sites. The presence of larger insects in restored woodland sites indicates the presence of higher trophic levels of insects there and likely indicates the presence of better food sources for insectivorous birds. Since 96% of birds rely on feeding insects to their young as a major protein source (Tallamy 2004), these restored woodland areas that support larger insects may well be providing important food resources for birds even beyond the more obvious benefit of seeds and fruit.

Considering the size of our sites and the relatively small amount of time spent collecting bird data, we still observed a large amount of bird activity. Data from restored woodland sites did produce a significantly higher Shannon index for birds than for the lawn areas. Although our small mammal sampling was even more limited, we find it noteworthy that small mammals were captured only in the restored woodland and forested areas (Table 1). The higher abundance and diversity of small mammals in these two habitats are likely due to the increased cover and food resources (plants, insects, and soil invertebrates). Together with our results of larger insects in restored woodland habitats, these bird and small mammal data provide further evidence that the restored woodland sites are capable of supporting higher trophic interactions. Although not assessed by this study, the higher abundance of small mammals in the restored woodland areas may provide subsequent benefit to predatory birds and terrestrial animals (anecdotally, we did notice that a garter snake has taken up residence in one of our restoration sites, and Cooper's Hawks are frequent visitors).

The consistent differences we report between restored woodland areas and lawn sites indicate that greater diversity at lower trophic levels (e.g., plants) supports greater biodiversity at higher trophic levels (e.g., insects, birds, and mam-

mals) (Dyer et al. 2010). However, studies in island biogeography have shown that this basic ecological principle is limited by context and by scale (Darlington 1957; Gotelli 2008). The distance from a source site is one such variable that could be affecting the ecological interactions within our restored sites. Nevertheless, Watt et al. (2006) have reported that there can be rapid recovery of insect-plant interactions in restored areas up to 800 m away from a source location. Therefore, the successful recruitment of higher levels of biodiversity to our restoration plantings has likely benefitted from the presence of remnant natural areas in the vicinity, both on campus and in adjacent properties.

Island biogeography has also identified the size of a habitat as a determining factor for biodiversity. Even though our restored sites represent very small habitat fragments, they appear to be supporting significant populations at higher trophic levels. It would be helpful for future studies to address the benefit to biodiversity provided by urban restoration projects as the size of project and distance from remnant natural areas varies. It is highly likely that land use around such restoration projects is also a major influence worthy of assessment. Applying island biogeography principles to urban restoration and reconciliation ecology approaches will help provide a theoretical grounding for this newly emerging field (Pickett et al. 2008).

As institutions and businesses are increasingly looking for ways to decrease their carbon emissions, we propose that incorporating native habitats in their landscaping is a worthwhile consideration (Steensma et al. 2013). Such areas not only negate the need for fossil-fuel emitting activities (e.g., mowing, blowing, edging) and chemical applications, they also protect the soil, diminish stormwater runoff, and act as carbon sinks. In addition, as is evidenced by these data and documented by other studies (Burghardt et al. 2009), even small native habitats will support greater biodiversity. In an age of habitat decline and accelerated extinctions, any advances in biodiversity preservation are valuable and should be supported.

We encourage efforts to further understand the benefits to biodiversity from native habitat restorations, particularly in urban and suburban landscapes. If plantings like those on the campus of Calvin College were implemented across an urban landscape—school yards, church grounds, and municipal parks hold great potential for such initiatives—and an archipelago of native habitats were to emerge, the benefit to native wildlife could be significant (Bennet 1990). Reconciliation ecology efforts like these raise interesting and important research questions, particularly with regard to how higher trophic level interactions are influenced by the distance from the nearest source habitat, the size of such plantings, the vegetational diversity employed, and the broader land-use context within which the plantings occur. Principles of island biogeography are certainly implicated, yet when natural nature is reintroduced into such a highly human-dominated context, new trends and patterns likely await discovery.

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NOTEWORTHY COLLECTION

WISCONSIN

Spiranthes ovalis Lindley var. *erostellata* Catling
Orchidaceae
October Lady's-tresses

Significance of the Report. The first report of this rare species from southeastern Wisconsin.

Previous Knowledge. This terrestrial, perennial herb ranges from Pennsylvania west to Iowa and south to Florida and Texas (Sheviak & Brown 2002). It has been reported to be spreading northward in the Midwest (Homoya 1993). *Spiranthes ovalis* var. *erostellata* was first discovered in southwestern Wisconsin by Mark Leach in 1990, growing on a steep wooded slope with "exposed limestone rocks nearby as well as pieces of chert" in Grant County (*Leach 1892*, WIS). There are two subsequent collections from this locality (*Leach 2892*, WIS; *Sime & MacGregor 06-01*, WIS). There are additional collections from two other localities with similar habitats elsewhere in Grant County (*Sime 07-13*, WIS; *Sime 06-02*, WIS). Although it has not been previously collected outside of Grant County in Wisconsin, there are unconfirmed reports from Lafayette and Crawford Counties, both of which are also in far southwestern Wisconsin (Wisconsin Department of Natural Resources 2014). *Spiranthes ovalis* var. *erostellata* occurs throughout most of Illinois, and was first discovered in the Chicago Region by Wayne Lampa at the Blackwell Forest Preserve in Du Page County in 1981; it was also found two years later by Dick Young and Jon Duerr in Kendall County (Swink and Wilhelm 1994). It was more recently collected in Cook County at Shoe Factory Road Woods in 2007 (*Rericha & Wilhelm 3633*, MOR) and at Palo Park (*Rericha & Krug 4007*, MOR) in 2010.

Discussion. A population of approximately 30 individuals of *Spiranthes ovalis* var. *erostellata* was observed in Waukesha County, Wisconsin, on October 3, 2014. The population was growing along a trail under a closed canopy of *Quercus macrocarpa* Michx. and *Ulmus americana* L. in association with a shrub layer dominated by *Rhamnus cathartica* L. and *Lonicera* ×*bella* Zabel and an herbaceous layer dominated by *Acalypha rhomboidea* Raf. and *Geum canadense* Jacq. Many of the orchids were at anthesis. Exposed dolomite bedrock was observed nearby. However, unlike the previous collections in Wisconsin, the area supporting the population was fairly level (slope estimated at < 5%). Inspection of aerial photographs taken in 1941 revealed that the population location was then at the edge of an oak woodland and that the adjacent area nearer Jericho Creek, now dominated by lowland hardwoods, contained few, if any, trees or shrubs (Waukesha County 2014). *Besseya bullii* (Eaton) Rydb. was observed in several relatively open areas nearby on the same property, suggesting a pre-settlement condition ranging from prairie to open oak woodland. The

FIGURE 1. Inflorescence of *Spiranthes ovalis* Lindley var. *erostellata* Catling at the collection site in Waukesha County, Wisconsin, on October 3, 2014. Photograph by Matthew Pace.

property owner is currently restoring oak woodland and savanna elsewhere on the property but has not managed the area where the orchids occur beyond keeping the trail free of debris. A digital photo was taken to serve as the voucher.

This locality, the first in Wisconsin outside of the southwesternmost corner of the state, is more than 100 km east of the previous collections in Wisconsin and about 100 km north of the nearest localities in northeastern Illinois. While this is a modest expansion of the known range, it is noteworthy because this orchid is critically impaired (S1) and a State Special Concern species in Wisconsin, rare in other states in the northern part of its range (it is State Threatened in both Iowa and Michigan and State Endangered in Pennsylvania), and occurrences are generally sparse throughout its range. It is not known whether the Wisconsin populations of this species are the result of a recent range expansion or if they were overlooked in the past, but the recent nature of this and other northern records is consistent with range expansion.

Diagnostic Characters. *Spiranthes ovalis* is subdivided into two varieties based on the capacity for out-crossing and column morphology. The typical allogamous (out-crossing) var. *ovalis* displays a fully formed rostellum and viscidium and is pollinated by bees (Catling 1980, 1983). The autogamous (self-pollinating) var. *erostellata* lacks both a rostellum and viscidium, allowing the pollinia to come into direct contact with the stigmatic surface, leading to self-pollination (Catling 1983). *Spiranthes ovalis* var. *ovalis*, is restricted to the Gulf coast region from Florida to Texas, whereas *S. ovalis* var. *erostellata* is more wide-ranging, being sparsely distributed throughout much of the lower eastern U.S., from Florida to southern Pennsylvania, and from eastern Texas to southern Wisconsin (Sheviak & Brown 2002).

Spiranthes ovalis var. *erostellata* (Figure 1) is characterized by its wholly white flowers, cupped lateral sepals, strongly narrowing and acute labellum that is less than 5.5 mm long, lack of a rostellum and viscidium, dark green oblanceolate leaves, the presence of at least one expanded cauline leaf at flowering time, and its preference for wooded and shady habitats. The populations of *S. ovalis* var. *erostellata* in Wisconsin bloom from the last week of September into early October. Together, these characteristics can be used to clearly differentiate this species from all other species of *Spiranthes* in the upper Midwest.

Spiranthes cernua (L.) Rich. is the only other autumn-blooming species that approximates *S. ovalis* var. *erostellata* in Wisconsin in general appearance, with which it shares a wholly white glabrous labellum and non-fragrant flowers. *Spiranthes cernua* may be distinguished by its larger rounded to subacute labellum 7-12 mm long with a crisped to lightly lacerate margin, fully formed rostellum and viscidium, and rounded, rather than slender, incurved callosities at the base of the labellum.

Specimen Citation. Wisconsin. Waukesha Co., Eagle Township, T5N, R17E, Sec. 24, SE¼ SE¼; Latitude 42.881917°N; Longitude 88.424785°W; approximately 30 plants along a trail in an area with dolomite near the surface at the Jericho Oak Woods. October 3, 2014, *Carter WI-0012* (WIS – digital photo, SEWRPC – digital photo).

ACKNOWLEDGMENTS

We would like to thank the property owners, Jacqueline Lewis and Richard Adduci, for welcoming us to the site.

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——Daniel L. Carter
Southeastern Wisconsin Regional Planning Commission,
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin, 53187
dcarter@sewrpc.org

——Matthew Pace
University of Wisconsin – Madison
Department of Botany
222 Birge Hall
Madison, Wisconsin 53706
mcpace@wisc.edu

REVIEWS OF STEVE W. CHADDE'S GUIDES TO THE WETLAND AND AQUATIC PLANTS IN THE GREAT LAKES REGION

Neil A. Harriman
Biology Department
University of Wisconsin-Oshkosh
Oshkosh, Wisconsin 54901
harriman@uwosh.edu

Steve W. Chadde. 2011. *Wetland Plants of Illinois: A Complete Guide to the Wetland and Aquatic Plants of the Prairie State.* 614 pp. ISBN 978-1463589264. Paperback. $30.95.

The publisher and author (same guy) tells us on Cover 4 that "Steve Chadde is a plant ecologist and former resident of Michigan's Upper Peninsula. After many years of field studies in the wetlands of the Midwest and Rocky Mountains, he is now retired and lives in the Philippines." And yes, he is the author of "Maayong Buntag!: An Introduction to the Visayan Language of the Philippines."

One precursor to this book, though unmentioned in the introductory matter, is Winterringer & Lopinot, "Aquatic Plants of Illinois," 1966. That book is a slender 142 pages, and took a narrower view of what's truly aquatic; for example, there are no species of *Carex* treated, whereas Chadde's work treats about 90.

Another precursor to this book is Mohlenbrock, "Aquatic and Standing Water Plants of the Central Midwest," in four volumes, 2005-2010, covering Illinois, Indiana, Ohio, Indiana, etc. This is likewise not mentioned in Chadde's book. The Mohlenbrock work includes 35 species of *Crataegus*, about two dozen of which occur in Illinois. They are included if they meet his criterion of "in standing water at least 3 months in a year." By contrast, Chadde has but one species of hawthorn. Obviously, these are very different approaches, not really comparable at all. Both works allude to the National Wetland Plant List, but clearly that was taken only as a starting point.

For each species treated in Chadde's work, there is a useful illustration (line drawing or photograph), a full description, and an Illinois range map. The county-by-county range is taken from ILPIN, the Illinois Plant Information Network, maintained by the Forest Service of the USDA. Their work is entirely in the public domain ("your tax dollars at work"), and is acknowledged in a segment called "References and Illustration Credits," pp. 589–590.

In terms of species nomenclature, Chadde takes a conservative view. For example, the segregates of *Polygonum* (*Fallopia, Persicaria*) are not accepted, The removal of many genera from traditional Scrophulariaceae into Plantaginaceae, Orobanchaceae, and Phrymaceae is not even mentioned. *Scirpus* is kept in its broad sense, but with synonyms in *Bolboschoenus* and *Schoenoplectus* also given.

The arrangement of the work is conventional: ferns, gymnosperms, dicots, monocots. Within those four segments, everything is alphabetical. A common

feature of Chadde books is that the family name is repeated in the running head on both the verso and the recto pages, a great convenience; in the present work, there are no running heads at all, which makes the book less than ideal.

Once again, Mr. Chadde has done well by his intended audience—land managers, plant ecologists, and lovers of wetlands.

Steve W. Chadde. 2012. *A Great Lakes Wetland Flora: A Complete Guide to the Wetland and Aquatic Plants of the Midwest.* Fourth Edition. vi + 683 pp. ISBN 978-1478194699. Paperback. $29.95.

"Midwest" is here taken to mean Illinois, Indiana, Ohio, Iowa, Michigan, Wisconsin, and Minnesota. Iowa is, of course, not at all within the Great Lakes drainage (nor are large portions of Minnesota, Indiana, Illinois, Wisconsin, and Ohio). The subtitle, "A Complete Guide . . . ." is a more accurate label for this book.

The volume includes all species for the area included in the National Wetland Plant List, abbreviated as NWPL, maintained by the U.S. Army Corps of Engineers, plus a number of species that are only occasionally to be found in wetlands. Hence, eleven species of *Viola*, which are sometimes to be found in floodplain forests and suchlike habitats, are treated. This is the pattern the author has followed throughout.

The keys are very thorough. The reader needs to distinguish pteridophytes, gymnosperms, and angiosperms (dicots and monocots). Throughout, the keys are dichotomous; if you've been working with keys for over half a century, like me, it's hard to judge whether a key is workable for the neophyte. But I think Chadde (two syllables) has done a good job. Every species has a range map, and a goodly fraction of the species are illustrated, either with photographs or with line drawings. The black-and-white photographs of various kinds of wetlands are very well chosen, and well reproduced.

The arrangement throughout is alphabetical. Difficulties arise with the question of how to delimit the families. In this work, it appears that the families are strictly the long-familiar ones of Engler & Prantl, or Gleason & Cronquist. Hence, the Plantaginaceae comprise only *Plantago* and *Littorella*, and the traditional Scrophulariaceae are left intact. Liliaceae are likewise maintained in the "classical" sense. For old-timers, there's no problem; for newcomers to the field, it's a different matter, if they've taken a modern course in Plant Taxonomy. It may be troublesome to readers, but there's no solution. The molecular evidence for familial and generic delimitation *can* be ignored, but it makes the book seem oddly dated and "old fashioned."

As with the families, the traditional genera are also maintained. Hence, we have *Aster*, with only a very restricted synonymy to indicate that the old genus is now divided up into numerous segregate genera, three of which appear in this work. In fairness to the author, he decided at the outset to correlate his work with the NWPL; therefore, he cannot serve two masters at once. I spot-checked a few families and genera to see if the NWPL is really that conservative, and it is. There is a very thorough index at the end of the book, which **has** to be used: if you are looking for *Acer* in the Sapindaceae (in a modern classification) by going through the book alphabetically, you're out of luck.

Steve W. Chadde. 2011. *Wetland Plants of Indiana: A Complete Guide to the Wetland and Aquatic Plants of the Hoosier State.* vi + 602 pp. ISBN 978-1466374164. Paperback. $30.95.

From the Indiana DNR website: "When Indiana was originally surveyed (1799 to 1834), the surveyors found and described broad areas of poorly drained wetlands. The wetlands of northwestern Indiana were chiefly wet prairie, while those of the northeastern section were more often swamps or bogs, dominated by woody vegetation. In 1816, about half of the surface area of northwestern Indiana was ponded during 6 months of the year. Benton County was more than half wetland. In 1834, Beaver Lake, in Newton County, occupied 28,500 acres."

And it goes on to say, "But the majority of these wetlands were not to last. More and more land was converted to agriculture, through dredging, draining, ditching, and damming. 1884 saw the start of major changes to the Kankakee River and its marshes by dredging, straightening the river, tiling and ditching the emergent lands. By 1917 Beaver Lake had shrunk from its 28,500 acres to 10,000 acres, and today exists in name only." The website also lists eleven wetland nature preserves in the state.

We can hope that Mr. Chadde's effort will further stimulate appreciation for Indiana's remaining wetlands. His book has excellent keys to families. The reader has first to distinguish ferns and their allies, gymnosperms, then angiosperms (monocots and dicots). He avoids technical terminology to the extent possible (and there is an extensive glossary, pp. 563–569). There is a separate "Woody Plant Key," again with every effort to use plain English.

All the species are illustrated, with photographs or line drawings, and distribution maps are given for each species, these generated from the USDA PLANTS database. This is a very different approach from that of Ed Voss, in his *Michigan Flora*, where a dot on a county meant that he himself had seen an actual preserved herbarium specimen. However, Chadde's intent is to aid the worker in putting a name to a thing, rather than "certifying" the known distribution of a species in Indiana. *Flora of Indiana* by Charles Deam, 1940, and now beautifully reprinted (BlackburnPress.com, full text also available online at http://archive.org/stream/floraofindiana00indi/floraofindiana00indi_djvu.txt), is still to be consulted, though Chadde's maps do include counties beyond those known to Deam.

Family delineation is traditional, and does not adhere to the usage of the Angiosperm Phylogeny Group. Hence, Aceraceae are not subsumed into Sapindaceae, Chenopodiaceae are not combined with Amaranthaceae, Scrophulariaceae are not remodelled, Liliaceae are kept in the broad sense, etc. The point is important because some workers will search in vain for Asparagaceae, Melanthiaceae, and the like. Given the book's alphabetical arrangement, the point is important.

Traditional *Scirpus* is maintained, with the segregate names (*Schoenoplectus* and *Bolboschoenus*) given in the synonymy. Again, this is a book about putting a name to a thing; it is not intended to be a critical taxonomic revision.

The omission of running heads with the family names is to be regretted. Imagine a dictionary (likewise alphabetical) without headers to orient the user.

The index is thoroughly done, and includes all the Latin names (including synonyms, rendered in italics) as well as common names.

Steve W. Chadde. 2012. *Wetland Plants of Michigan: A Complete Guide to the Wetland and Aquatic Plants of the Great Lakes State.* Second Edition. vi + 684 pp. ISBN 978-1481194945. Paperback. $24.48.

Michigan is known as the "Great Lake State," as formerly emblazoned on automobile license plates. Mr. Chadde's title offers a variant on that theme.

The book features workable keys, range maps, concise descriptions, and photographs or line drawings of a great many of the species. It includes the ferns and fern allies.

The classification of the National Wetland Plant List is not followed here, even though its ratings (obligate wetland plants, facultative wetland plants, etc.) are. Some of the nomenclature of modern floristic work is adopted; for example, *Aster* now disappears, replaced by its segregates *Symphyotrichum, Oclemena*, and *Doellingeria*; the other segregates of classical *Aster* do not occur in Michigan wetlands. The segregates of traditional *Scirpus* (i.e., *Bulboschoenus*, *Schoenoplectus*, etc.) are recognized, There is enough synonymy given that one can easily coordinate with the List, if need be.

The adopted generic names are consonant with those given in Voss & Reznicek, *Field Manual of Michigan Flora*, 2012 (a work that does not include ferns and fern allies). However, the family delimitations are somewhat at odds: Voss and Reznicek have adopted the Angiosperm Phylogeny Group delimitations of families, such that Aceraceae are subsumed into Sapindaceae, Liliaceae are splintered into a number of satellite familes, and Scrophulariaceae now have most of their traditional genera distributed elsewhere (Plantaginaceae, Phrymaceae, Orobanchaceae, etc.). Because Chadde's book is alphabetical (though still split into pteridophytes, gymnosperms, and dicots plus monocots), the problem of working from one to the other may be frustrating to some. It's always been true, that a plant ecologist (as Mr. Chadde labels himself) has first to be a plant taxonomist. With the current "molecular" aspects of plant classification coming to the fore, both the ecologist and the taxonomist have to be on their toes. Perhaps it is time for writers of floristic works to have a grand congress and arrive at a *modus vivendi*.

The intended audience for this book is plant ecologists, land managers, consultants, and the general public who enjoy the aesthetic beauty of wetlands. They have all been well served by Mr. Chadde.

Steve W. Chadde. 2012. *Wetland Plants of Minnesota: A Complete Guide to the Wetland and Aquatic Plants of the North Star State.* Second Edition (Revised). vi + 664 pp. ISBN 978-1477645178. Paperback. $24.95.

The North Star State has long been known, though informally, as "The Land of 10,000 Lakes." That legend still appears on some Minnesota license plates.

But Google will tell you in big, bold letters that the state actually has 11,842 lakes over ten acres in size. Chadde's book will find a ready audience.

Best I can tell, there is no other current identification manual on the wetland plants of Minnesota. There exists Eggers & Reed, 1987, *Wetland Plants and Plant Communities of Minnesota & Wisconsin.* But this covers just over 100 species, and there are no keys; it is much more concerned with community ecology than taxonomy. By contrast, Mr. Chadde's book covers over 800 vascular plant species. His keys work. The accompanying line drawings and photographs for nearly every species are generally quite useful. The distribution maps are helpful; they are generated from bonap.org.

Chadde's book is not, and is not meant to be, a modern taxonomic treatise. For example, he treats two species of *Cacalia*, despite the fact that the generic name is a *nomen utique rejiciendum*, a name always to be rejected, and has had that status in the Code since 2000. If one searches for *Cacalia* in the National Wetland Plant List, version 3.2 of 2014, one is dropped into *Arnoglossum.* It may well be, however, that it was a different matter when Chadde compiled this book. A major source which Chadde cites is Anita Cholewa's *Comprehensively Annotated Checklist of the Flora of Minnesota*, version 2011.2. For *Cacalia suaveolens*, she adopts *Hasteola suaveolens*, as does Flora North America; Chadde merely cites that combination in synonymy.

The alphabetical sequence of this book makes it easy to find things, without resorting to the excellent index. The reader has only to keep in mind that the genera are those of hoary tradition, and for the most part so are the families: *Aster,* not *Symphyotrichum; Scirpus*, with its segregate names in synonymy; Asclepiadaceae, Aceraceae, Liliaceae—all in the traditional sense. One may mention in passing that Cholewa adopts the Angiosperm Phylogeny Group family names *in toto*. Well, almost: Talinaceae and Montiaceae are not adopted in her list, because she elected to be faithful to Flora North America, where those two families were not recognized as segregates from Portulaceae. Mr. Chadde, perhaps rightly, elected to stick with tradition.

The volume features very complete headers, so necessary when everything is alphabetical. As appropriate, the headers include the Latin name of the genus on that page, which is very helpful.

On page 5, Mr. Chadde explains a bit about binomial nomenclature, and points out that binomials are to be followed by an "authority." In the current Code, the term "author" is used, not "authority." As far back as the first Code, *Lois de la Nomenclature Botanique*, by Alphonse de Candolle, 1867, only the term "author" is used, as is true of all the subsequent Codes, from the Vienna Code of 1905 to the present. It would be the work of many years to discover when "authority" first came into use; but Liberty Hyde Bailey, 1949, *Manual of Cultivated Plants*, devotes sixteen pages to "Authorities for the Binomials," which is the oldest place I've seen this [mis]usage. (Bailey also refused to use parenthetical authors, and insisted on inserting a comma between the Latin binomial and the author, contrary to the Code then in force.) Neither Mr. Chadde nor I am going to look any further.

Steve W. Chadde. 2013. *Wetland Plants of Wisconsin: A Complete Guide to the Wetland and Aquatic Plants of the Badger State.* Second Edition. vi + 658 pp. ISBN 978-1481982221. Paperback. $26.95.

Wisconsin has 3620 inland lakes larger than 20 acres. Wisconsin DNR estimates the state originally had about 10 million acres of wetlands, of which about 5.3 million acres still exist. Clearly, there is a need for Mr. Chadde's book – he grew up in Wisconsin, in Kenosha, midway between Milwaukee and Chicago, and in some ways this is a "return to his roots," I think.

The keys, descriptions, illustrations, and range maps are useful and functional. I think his intended audience will have no difficulty putting a name to a thing, which is his stated intention. The keys are notable for their clarity and avoidance of technical jargon, to the extent possible.

The arrangement is alphabetical: ferns and their allies, gymnosperms, and angiosperms (dicots and monocots). It is most helpful that Chadde has provided headers for every page, dictionary-like, to facilitate finding one's family, genus, and species. Over 800 species are covered. There is no other work like this for the state.

The family circumscriptions are the traditional ones and do not conform to the scheme of the Angiosperm Phylogeny Group. In the Liliaceae as treated here, for example, the author simply gives the APG family assignment at the end of the treatment of each species. Some of these "micro-family" designations are themselves out of date: *Maianthemum*, said to fall into Ruscaceae, is now accommodated in Asparagaceae. Chadde notes that "Some newer treatments of the Lily Family sometimes separate the various genera into new families; these are noted below." The families are not new; Asparagaceae date from 1789, Ruscaceae from 1840. None of this has anything to do with wetland or aquatic plant studies, obviously, but the reader risks being led astray when things are arranged alphabetically.

The "References" section of the book, pages 625–626, is a helpful compendium, especially because it includes websites. *Vegetation of Wisconsin* dates from 1959; the date given (1971) is that of a verbatim reprint. *Michigan Trees* is cited from 1981, but there is a 2004 update. The index to the whole book is quite thorough, including both scientific and common names; the accepted names are in plain type, the synonyms in italics, but family names mentioned only in passing, like Ruscaceae, are omitted.

The Glossary, pages 613–619 is very thorough, even including some ordinary English words like "thicket" and "tree." Here and there, when descriptive words keep their Latin plurals, like "sorus, sori" or "indusium, indusia," these are so indicated. The characterization of a cone as "the dry fruit of conifers" will raise eyebrows, especially because on page 66 the author very nicely explains that conifers are gymnosperms, which is explained as "naked seed," the seed not enclosed in an ovary. A nomenclatural variety is said to be a subdivision of a subspecies, which is logical but incorrect.

BOOK REVIEWS

Gil Nelson, Christopher J. Earle, and Richard Spellenberg. 2014. *Trees of Eastern North America.* Princeton University Press, Princeton, New Jersey. 720 pp. ISBN 978-0-691-14591-4. Flexibound. $29.95. ISBN 978-0-691-14590-7. Hardcover. $65.00.

This is an entry in the excellent series of Princeton Field Guides. It covers 825 species in an area whose western boundary is the 100th meridian, which lies slightly to the west of the middle of the Great Plains states of the Dakotas, Nebraska and Kansas and just cuts off the panhandles of Oklahoma and Texas. Northward, the line runs just east of the western boundary of Manitoba. There is a companion guide to the trees of western North America (not seen) published at the same time and by the same authors, but in a different order (Spellenberg, Earle, and Nelson) that covers 630 species. The coverage includes all species of trees that are native to or naturalized in the area of coverage, as well as prominent cultivated street and garden trees. A number of shrubs that are generally taller than a human are also included, though there is no indication as to how complete this representation of "large" shrubs is.

For each species, there is a rather detailed description, a short statement of the habitat and range of the plant, a distribution map (for native species only), and a brief statement describing how the species differs from related species. Sometimes this is followed by a paragraph entitled "Note," which contains additional interesting information about the plant. At the head of each entry is a short paragraph in boldface type, referred to as "Quick ID," that very briefly gives one or two characters meant to serve as identifying characteristics for the species. Each species entry is accompanied by color paintings by David More. Although the elements of the illustrations vary somewhat, most contain an image of a full open-grown tree and details of flowers, fruits, leaves, twigs (including buds), and often a slab of bark. Sometimes a full branch is illustrated to show the arrangement of leaves and/or flowers and fruits in relation to each other.

A drawback to this book for serious users is that there are no dichotomous keys. Instead, in the introduction there are eight pages of small paintings of leaves under the heading, "Key to Selected Angiosperm Trees by Leaf Shape." The first problem is apparent in the word "Selected," which makes it clear that this "key" is incomplete, and there is no indication of how incomplete it is. So, at the outset, there is no guarantee that the particular tree you are trying to identify is even included in the key. Then one scans the eight pages for particular categories—there are 32 leaves illustrated under the heading, "Simple Leaves, Margins entire, Leaves Opposite," 61 under "Simple Leaves, Margins Entire, Leaves Alternate," and 45 under "Simple Leaves, Margins Toothed, Leaves Alternate," to mention three categories. There are no further divisions under these broad headings. Nor is there any indication of what the important characters are for any given illustration, whether it is the shape of the apex or the base, the ratio of width to length, the length of the petiole, the vestiture, characters of the venation, the presence or absence of glands, or anything else. Each illustration is accompanied solely by the English name of a

tree and a page number. It will be obvious at once to anyone at all familiar with the wide variability of individual leaf shapes, even on a single tree, that an attempt to make an accurate identification using this "key" is likely futile. This is preceded by five pages of paintings of "Winter Twigs of Selected Eastern Trees," again divided into various broad categories. The 167 species so illustrated constitute a mere 20% of the 825 species included in this field guide.

Considered in isolation, this is unquestionably an excellent field guide—it offers complete coverage, excellent illustrations, distribution maps, and aids to identification. But there are many other guides to trees that cover all, or a portion, of the same area, and one must ask whether this book offers anything that others do not, or whether what it does offer is better than what other field guides offer. In my view, the answer to both questions is "No."

For serious use in the field, it is generally preferable to use a guide that is more localized, covering, for example a single state or similar region. It is much easier to identify an unknown oak from among the 12 species included in Barnes and Wagner's *Michigan Trees* (revised and updated edition), the 20 included in *Native Trees of the Midwest* (second edition), by Weeks et al., or the 21 included in *Trees of Missouri*, by Don Kurz, than from among the 45 species included in this field guide. In addition to a more localized coverage, each of these guides contains useful aids to identification that are lacking in Trees of Northern America. Three of them have full dichotomous keys, to families, to genera within families, and to species within genera, often including separate keys to summer and winter material. The Michigan and Missouri guides contain superb line drawings for each species, including separate drawings of leaves, buds, flowers, fruits, winter twigs, and more, and occupying an entire page for the illustration of a single species. The Midwest guide has detailed close-up photos of the same features, again with a single species to a page. All have detailed descriptions, and the Missouri guide puts those parts of the descriptions that are particularly valuable for identification in boldface.

A particularly useful comparison is with Thomas Elias's *The Complete Trees of North America*. This is almost exactly the same size and thickness as *Trees of Eastern North America*, but, like the more focused guides already discussed, has many identification features that are lacking in the newer guide—full dichotomous keys, arrows on the drawing pointing out important characteristics, and boldface to emphasize those passages in the detailed descriptions that are particularly useful for identification.

One wonders what audience this book is intended for. There is no indication either in the introductory material or on the cover, save for the statement at the end of the front jacket flap that "this is an essential guide for every tree lover." For the beginner, there are other guides that are more usefully localized and permit more accurate identifications; for the expert, it is too lacking in the standard methods of identification, not to mention any synonymy, to make it useful for field use. It is comprehensive and up-to-date. The descriptions are thorough, and the illustrations are excellent. It can profitably be used in conjunction with other guides, and will serve as a useful shelf reference. I will undoubtedly consult it from time to time. But it cannot be recommended as a first choice for field identification.

——Michael Huft

Stewart McPherson and Donald Schnell. 2012. *Field Guide to the Carnivorous Plants of the United States and Canada.* Redfern Natural History Productions Ltd., Poole, Dorset, England. 200 pp. ISBN 978-1-908787-08-8. Soft cover. £12.99. Available from: http://www.redfernnaturalhistory.com/

This welcome field guide to the carnivorous plants occurring in North America is a handy book that can easily be carried out in the field. Perhaps the thing that strikes one first is the stunningly beautiful photographs, some of which are presented as full-page images, without borders. The field guide is profusely illustrated with 300 images, (most of them provided by Stewart McPherson and Barry Rice, but some contributed by 36 other photographers, and covers four families (Bromeliaceae, Droseraceae, Lentibulariaceae, Sarraceniaceae), eight native genera (*Catopsis*, *Dionaea*, *Drosera*, *Pinguicula*, *Utricularia*, *Darlingtonia, Sarracenia*), and 47 species. Numerous infraspecific taxa are also included, chiefly varieties and color forms within the genus *Sarracenia*—perhaps as a consequence of the authors having just published a new book on the Sarraceniaceae (McPherson and Schnell 2011). Also included in this field guide is an Old World aquatic plant of the Droseraceae, *Aldrovanda vesiculosa* (waterwheel plant), apparently recently introduced locally in New York, New Jersey, and Virginia.

The book is organized alphabetically, first by family—giving brief comments—then by genus, with brief generic information, a section on plant structure for the genus, a generalized diagram representing the genus, and comments on habitat and ecology. Species are then alphabetically arranged, giving scientific name and author, common name, literature for the original description (although none cited for taxa transferred to another genus or changed to another taxonomic level), and derivation of specific epithet, along with general geographical distribution (no maps), habitat, descriptive features (vegetative and floral), and occasionally taxonomic comments. Toward the end there is a section enumerating natural hybrids of North American carnivorous plants. The book concludes with a brief discussion addressing issues of conservation of North American carnivorous plants. I only wish that the book included some kind of key to help distinguish those taxa that are rather similar—although the text does address potential problems of misidentification of certain "look-alikes" and "species pairs." There is no table of contents, and no index.

Although a wealth of information is presented in this handy "field-friendly" book, I was surprised to find a bibliography of only two references. Perhaps this is because the authors feel that their other published works more fully cite literature sources. For instance, Schnell's *Carnivorous Plants of the United States and Canada*, 2nd edition (Schnell 2002) provides an extensive bibliography citing his sources. And I was also surprised that none of the 300 images is attributed to Donald Schnell. Was this to avoid duplication of information he presented in his second edition? Should that be the case, I believe it appropriate to emphasize that this new field guide does not replace Schnell's classic reference on our native carnivorous plants, which is full of very valuable information on the biology of these fascinating plants as well as on their taxonomy, and which is well-illustrated with many excellent photos and diagrams.

As one would expect with any work dealing with taxonomic diversity, not all

botanists will be in agreement as to the taxonomy adopted. For instance, in my taxonomic treatment of Lentibulariaceae for *Flora of North America North of Mexico* (Crow, in press), I treat *Utricularia macrorhiza* as a subspecies within *Utricularia vulgaris* (as *U. vulgaris* subsp. *macrorhiza* (Laconte ex Torrey) R. T. Clausen). I made this decision after careful comparison of specimens of the European *U. vulgaris* subsp. *vulgaris* with North American specimens; given the variation exhibited in these plants and the very minor differences between the two taxa, I felt it best to treat these as a single species. Furthermore, after a re-examination of my own specimens collected from western Siberia demonstrated that those specimens also belong to subsp. *macrorhiza*, I came to the realization that subsp. *macrorhiza* is the taxon with the greater geographical range (North America and eastern Asia westward to western Siberia). Similarly, I regard what is treated in the *Field Guide* as *Pinguicula macroceras* as conspecific with *P. vulgaris*—the differences being extremely minor—yet I retain subspecific rank for the usually larger-flowered subsp. *macroceras*, because the geographic ranges are largely allopatric; yet occasionally specimens occur that cannot be readily assigned to either taxon.

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——Garrett E. Crow
Michigan State University Herbarium
East Lansing, Michigan, USA
garrett.crow@unh.edu

ANNOUNCEMENTS

NOMINATIONS ARE NOW BEING ACCEPTED FOR THE ISOBEL DICKINSON MEMORIAL AWARD

The Isobel Dickinson Memorial Award was established in 1993 by the Red Cedar Chapter of the Michigan Botanical Club to acknowledge the best student-authored paper published in *The Michigan Botanist*. Isobel Adkins Dickinson (1921-1993) was a founding member of the Chapter and served as its Treasurer, Secretary, and Director-at-large over a twenty-year tenure. She is fondly remembered for her enthusiastic service to Michigan Botanical Club and her devotion to botany in general. This award has been set up in her memory.

We are pleased to report that the award for **best student-authored paper** published in *The Michigan Botanist* Volume 51 was presented to **Kelsey Huisman** and **Alex Graeff** for their well written article on "Hybridization Dynamics of Invasive Cattail (Typhaceae) Stands at Pierce Cedar Creek Institute: A Molecular Analysis," Kelsey Huisman, Alex Graeff, and Pamela J. Laureto, The Michigan Botanist 51: 89–99.

Nominations are now being accepted for articles appearing in Volume 52 of *The Michigan Botanist*. In order to be eligible: 1) the student must have been at least a half-time student in any High School, Adult or Trade School, College, or University, and 2) the nominated article must have undergone the standard peer-review process and have been published in *The Michigan Botanist* in the volume under consideration for a given year's award.

NOMINATIONS CONSIST OF AND MUST INCLUDE EACH OF THE FOLLOWING:

1. Nominee's full name, address, phone number, and email address.
2. The Article's title, volume and issue number, pagination, and date.
3. If co-authored, statement of the percentage of total effort the student made in the article's (a) research, (b) research funding, and (c) writing.
4. Affirmation that the nominee is at least a half-time student, and provide the school's name, address, and contact information of the advisor.
5. A brief paragraph stating why this article/student should be considered for this award.
6. The name, address, phone number, and email address of the nominator (self nominations are acceptable).

Nominations will be accepted for 6 weeks after the final issue of a volume is published. Final selection will be at the discretion of the Dickinson Award Committee. Announcements and the award will follow shortly thereafter. The committee reserves the right not to make the award for any given year. All decisions of the committee are final. Nomination Forms are available at the Michigan Botanical Club website: http://michbotclub.org/isobel-dickinson-memorial-award. Questions and nominations may be directed to Irene Eiseman, Chair, Dickinson Award Committee, 1873 Pierce Road, Chelsea, MI, 48118; email: eisemani@gmail.com.

REVIEWERS FOR VOLUME 52

I wish to thank the following people who reviewed manuscripts for Volume 52 of The Michigan Botanist. Their comments were important, both to the authors and to the editor, and their efforts, which are essential to maintaining the high quality of the journal, are greatly appreciated. In addition, I wish to thank those reviewers whose names are unknown to me who reviewed articles appearing in Volume 52 prior to my becoming editor.

Carol Augspurger
Garrett Crow
Michael Homoya
Emmet Judziewicz
Neil MacDonald
Anna Monfils
Larry Nooden
Heather Reynolds
Anton A. Reznicek
Paul Rothrock
Michael Rotter
Dan Skean
Wm. Wayt Thomas
Sally Weeks

INSTRUCTIONS TO AUTHORS

Refer to http://quod.lib.umich.edu/m/mbot/submit for more detailed instructions, especially for formatting, style conventions, literature cited, and voucher specimen requirements. Please contact the editor with any questions.

1. Create text in 12-point Times New Roman font and double space paragraphs throughout. Research articles should be organized as follows: Title, Author(s) and address(es), Abstract with up to 5 keywords, Introduction, Materials and Methods, Results, Discussion, Acknowledgements, Literature Cited, Tables, Figure Legends, and Figures. Sections may be omitted if not relevant. All pages should be numbered.

2. For noteworthy collections, manuscripts should be formatted as follows. The title, "Noteworthy Collections," should begin each submitted manuscript, followed on the next line by the State or Province for the species reported. The next line should list the taxon of interest using the following format: Species Author(s) (Family). Common name. The rest of the manuscript should include the following named sections: (i) Significance of the Report, (ii) Previous Knowledge, (iii) Discussion, (iv) Diagnostic Characters (if desired), (v) Specimen Citations, (vi) Acknowledgements (if desired), and (vii) Literature Cited. Each of these sections is largely self-explanatory; however, the "Significance of the Report" section should be limited to a brief sentence or phrase indicating the significance of the collection(s), and this may be expanded upon in the "Discussion" section; the "Specimen Citations" section should include the relevant label data from the voucher specimen(s) including location data, collector(s), collection number, etc., as well as the Index Herbariorum acronym(s) of the herbarium or herbaria where the specimen(s) are deposited. The manuscript should end with the name and address of the author(s).

3. Non-research articles, such as book reviews, letters to the editor, notices, biographies and other general interest articles can be formatted as general text without the specific sections listed above. However, literature cited and any tables or figures should be formatted as described below.

4. Create tables either as an MS Word table or using a tab-delimited format. Each table is to be submitted as a separate file. Table captions should be placed at the top of the table. Any footnotes should appear at the bottom of the table. Please do not insert tables within the body of the text.

5. Send each figure as a separate file in a high-resolution format—eps, jpg, or tif. Figures like bar graphs that gain their meaning with color won't work—use coarse-grained cross-hatching, etc. Create figure legends as a separate text file, and the typesetter will insert them as appropriate. Please do not insert the figure in the body of the text file.

6. Citations: Please verify that all references cited in the text are present in the literature cited section and vice versa. Citations within the text should list the author's last name and publication year (e. g. Smith 1990). For works with more than 2 authors, use "et al.", and separate multiple citations with a semicolon.

7. Literature Cited: List citations alphabetically by author's last name. The first author's name is to be listed with surname first, followed by initials (e.g. Smith, E. B.), and subsequent authors are to be listed with initials first.Separate author's initials with a single space. The year of publication should appear in parentheses immediately before the title of the citation. The entire journal name or book title should be spelled out. Please put a space after the colon when citing volume number and page numbers.

8. Italicize all scientific names. Voucher specimens must be cited in floristic works and in any other study whose results depend on the identity of the plant(s). Papers citing plant records without documenting vouchers are generally not acceptable.

9. Manuscripts must be submitted electronically to the email address of the editor. All manuscripts will be reviewed by at least two referees.

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On the cover: Pitcher's Thistle, *Cirsium pitcheri,*
Sleeping Bear Point, Sleeping Bear Dunes National Lakeshore,
Leelanau County, Michigan.
Photo by Noel B. Pavlovic